International Geology Review

Vol. 3, No. 4 April 1961

PARTIAL CONTENTS

- complete table of contents inside -

published by the
AMERICAN GEOLOGICAL INSTITUTE

The American Geological Institute operates under the National Academy of Sciences. It is governed by an Executive Committee and a Board of Directors composed of two directors from each of the Member Societies.

International Geology Review is published monthly by the American Geological Institute with the assistance of an initiating grant from the National Science Foundation. The journal will report, in English, significant contributions to pure and applied research in the earth sciences which appear in foreign-language journals, especially those published in the U.S.S.R.

The editors of International Geology Review will give consideration to full English translations, condensations, and reviews submitted voluntarily for publication. Translators will be appropriately credited.

Readers are invited to direct to the editors their comments and discussions of articles published in the International Geology Review. Readers are encouraged also to submit suggestions as to published foreign literature considered worthy of translation and publication. Such suggestions should relate to materials of broad, general interest, rather than materials of limited reader interest.

Address editorial and subscription inquiries to

AGI TRANSLATIONS OFFICE
AMERICAN GEOLOGICAL INSTITUTE
2101 Constitution Avenue, N.W., Washington 25, D. C.

The basic subscription rate for International Geology Review is $55 per year, 12 issues. A special subscription rate of $15 per year is available to members of AGI Member Societies who are on the GEOTIMES mailing list. The $15 per year subscription rate is also available to educational institutions and personnel. Foreign postage: No additional charge to Canada and Mexico; to Pan American Union countries add $0.50 per year; to all other foreign countries add $1.00 per year. Single copy price $5.00 ($1.50 to subscribers qualifying for special rates). Second class postage paid at Washington, D. C.

International Geology Review

published monthly by the
AMERICAN GEOLOGICAL INSTITUTE

Vol. 3, No. 4 April 1961

CONTENTS

IGR TRANSLITERATION OF RUSSIAN

The AGI Translation Office has adopted the essential features of Cyrillic transliteration recommended by the U. S Department of the Interior, Board on Geographic Names, Washington D. C.

Alphabet		transliteration
А	а	a
Б	б	b
В	в	v
Г	г	g
Д	д	d
Е	е	e, ye (1)
Ё	ё	ë, yë
Ж	ж	zh
З	з	z
И	и	i (2)
Й	й	y
К	к	k
Л	л	l
М	м	m
Н	н	n
О	о	o
П	п	p
Р	р	r
С	с	s
Т	т	t
У	у	u
Ф	ф	f
Х	х	kh
Ц	ц	ts
Ч	ч	ch
Ш	ш	sh
Щ	щ	shch
Ъ	ъ	" (3)
Ы	ы	y
Ь	ь	' (3)
Э	э	e
Ю	ю	yu
Я	я	ya

However, the AGI Translation Office recommends the following modifications:

1. Ye initially, after vowels, and after ъ, ь Customary usage calls for "ie" in many names, e. g., SOVIET KIEV, DNIEPER, etc.; or "ye", e. g., BYELORUSSIA, where "e" follows consonants. "e" with dieresis in Russian should be given as "yo".
2. Omitted if preceding a "y", for example, Arkhangelsky (not "iy"; not "ii").
3. Generally omitted.

NOTE: Well-known place and personal names that have wide acceptance will be used. Some translations may include elements of previous German transliteration from the Russian; this occurs in IGR most commonly in maps and lists of references. The reader's attention is called to the following variations between German and English systems which may cause confusion when trying to check back to original Russian sources.

German	English
w	v
s	z
ch	kh
tz	ts
tsch	ch
sch	sh
schtsch	shch
ja	ya
ju	yu

TENTATIVE CONTENTS FOR THE MAY 1961 ISSUE

SEISMOLOGY IN THE U.S.S.R.

By

Peter Dehlinger

CONTENTS

INTRODUCTION

Seismology has been developing rapidly in the U. S. S. R. since 1945. Even a casual review of Soviet literature indicates that the U. S. S. R. appears to be more advanced in certain phases of seismology than are other countries. A systematic review of Soviet literature in seismology is therefore desirable. The purpose of this review is to establish a plateau from which Soviet seismology can be viewed. This review attempts to summarize Soviet published literature in seismology as of about December, 1959.

Approximately 330 articles and books, listed in the references, were used in this review. Most of the referenced material was available in English as abstracts or translations of the entire paper. Some, however, were available only as titles or were scanned briefly in the original Russian.

It appears that the Soviets are attempting to extend basic and applied knowledge in every phase of seismology. This approach has resulted in a systematic, well coordinated, and all-inclusive program in seismology that incorporates sizeable government agencies, a large number of highly trained scientists, and funds for operation which have been estimated to be considerably larger than those expended in the United States.

The major research and investigations in Soviet seismology are conducted at the Institute of Earth Physics (formerly the Geophysical Institute), and its field stations, of the U. S. S. R. Academy of Sciences. All phases of seismology are being studied at this Institute by a large staff of highly trained scientists, including more than 100 geophysicists, physicists and mathematicians. The Institute also awards doctorate degrees in seismology. Other Soviet organizations are active in seismology, but to a lesser extent. These include the Council on Seismology of the U. S. S. R. Academy of Sciences, the Institute of Geophysics of the Georgian S. S. R. Academy of Sciences, Moscow State University, Leningrad State University, the Leningrad Division of the Mathematical Institute of the U. S. S. R. Academy of Sciences, the All-Union Research Institute of Geophysical Methods of Prospecting, the All-Union Institute of Methods and Techniques for Prospecting, other organizations under the Ministry of Geology and Conservation of Natural Resources, and certain republic academies of science.

Among the main problems of Soviet seismology are the study of the physical properties of various types of seismic waves propagated in different media, especially layered media; the determination of criteria for recording and identifying wave groups; and the development of instruments to record, analyze, and process data. The most significant Soviet developments during the last fifteen years include mathematical analyses of wave propagation, especially spherical waves reflected and refracted from layered media; the mechanism at the source of an earthquake; frequency analyses of seismograms to differentiate wave group on the basis of frequency content; utilization of amplitudes on seismograms, particularly in explosion seismology, to determine absorption coefficients in rocks; construction of "dynamic" travel time curves for data interpretations, which includes wave amplitudes and frequency spectra in addition to the conventional arrival times and velocity data; development of the refraction-correlation shooting procedure, which has a higher resolving power than conventional refraction techniques; utilization of seismometer arrays to improve signal-to-noise ratios, especially for recording distant explosions; seismic zoning relating seismicity quantitatively with tectonic activity, which has application in locating new engineering sites, industrial plants, and even new cities; and development of significant aproaches for indirectly detecting underground explosions. Other advances, though less striking, have been made in nearly all phases of seismology. Clearly, the Soviets are major contributors in seismology.

For the purposes of this review, Soviet seismology has been grouped into four subjects: 1) theoretical and laboratory investigations, 2) earthquake seismology, 3) explosion seismology, and 4) instrumental seismology. Emphasis has been placed on principles, concepts, and techniques which the Soviets are using and developing, not on descriptions of particular earthquakes or prospecting areas. Under instrumental seismology, the broad instrumental developments only are discussed, not the details of individual instruments.

SOVIET RESEARCH AND INVESTIGATIONS IN SEISMOLOGY

Soviet research and investigations in seismology have been described in detail in the open literature and at numerous technical meetings. Reports of these meetings provide a significant addition to the published literature.

Theoretical and Laboratory Investigations in Seismology

Soviet research and investigations in theoretical seismology and in various types of lab-

ratory investigations are significant and ef-
ective. Pertinent investigations are indicated
the following sections.

Elasticity Theory

A limited number of Soviet papers have been
iblished on the mathematical theory of elas-
city during the last five years. Most of these
ere published in the Izvestiya, Seriya Geo-
zicheskaya; Doklady; and Prikladnaya i Mekh-
nika; all of the U. S. S. R. Academy of
ciences. The principal authors in elasticity
eory have been G. A. Skuridin, N. V. Zvolin-
kiy, G. I. Petrashen', A. A. Gvozdev, and Ye. I.
nemiakin.

Dynamic elasticity problems using asymptotic
ethods and boundary conditions for non-
nalytic solutions have been investigated by
kuridin [1-4] and co-workers. Petrashen' and
o-workers have investigated the dynamic theory
f elasticity for media containing cylindrical
nd spherical boundaries [5], and have also in-
estigated asymptotic representations of cylin-
rical functions [6]. Other significant papers are
y Shemiakin, on the propagation of disturbances
imperfectly elastic media [7], and by Mikhlin,
n investigations of elasticity equations for non-
omogeneous media [8].

Wave Propagation Theory

Approximately 300 Soviet articles and books
ere noted on wave propagation theory. Avail-
ble were complete translations of numerous
apers, and abstracts of approximately 100.

Soviet knowledge on wave propagation theory
perhaps best indicated by the book of L. M.
rekhovskikh [9], "Waves in Layered Media"
957). This is a major contribution containing
xtensive analyses not found in the Western
terature. This book, which has been translated
to English, contains numerous diagrams and
quations and is written for the mathematical
eophysicist. It lists 238 references; 131 to
Vestern and Japanese authors, and 107 to Soviet
uthors or materials translated into Russian.
he Soviet works cited are significant, despite
e large number of non-Soviet references.

Brekhovskikh appears to be the most prom-
ent Soviet contributor to wave propagation
eory; others are Yu. V. Riznichenko, B. N.
akin, K. I. Ogurtsov, G. I. Petrashen', V. I.
eylis-Borok, N. I. Davydova, N. V. Zvolinskiy,
nd I. S. Berzon.

ody Wave Propagation: Brekhovskikh has
ublished on wave propagation since about 1946.
uch of his research is described in his book,
Waves in Layered Media" [9], which treats,
length, plane and spherical waves propagated
cross layered media.

Petrashen' [10] has edited a three-volume monograph, "Data on Quantitative Studies of the Dynamics of Seismic Waves". It include tables, graphs, explanatory text, and discussions of the dynamic properties of seismic waves which are required for construction of theoretical seismograms corresponding to isotropic layered media. Additional tables pertain to functions for the initial point source, to conversion and reflection coefficients for waves reflected from the earth's surface, the formation of head waves, and complex forms of the reflection and refraction coefficients of transverse SH waves. Methods of measuring amplitude-phase-frequency characteristics on seismograms are also discussed. The purpose of these volumes was to facilitate identification of arrivals of various waves on seismograms. Petrashen' has also described the Lamb problem for an elastic semi-space [11] and has investigated body wave propagation in a medium with dipping layers [12]. At a symposium in Moscow ("Symposium 1; Questions on the Dynamic Theory of Seismic Wave Propagation," Gostoptekhizdat, Moscow-Leningrad, 1957), he discussed the quantitative theory of reflected and head waves generated in stratified media with plane parallel interfaces.

Riznichenko has published on wave propagation since 1938. Most of his papers pertain to seismic velocity determination in isotropic and heterogeneous media. Riznichenko's more recent studies pertain to models, discussed further in this review under "Ultrasonic Models".

Ivakin has developed a theory on the dynamic similarity between ultrasonic models and seismic phenomena [13]. He has also discussed propagation in a liquid medium containing a thin high-velocity layer [14], in which the propagation of PPP and PSP waves were investigated with ultrasonic models. The results were presented in terms of layer thickness and rigidity, and in terms of the energy ratio PSP/PPP. In another paper he investigated the micro- and macro-structure of waves in heterogeneous media [15].

Ogurtsov and co-workers have discussed propagation in an elastic half-space and in an elastic half-space with axial symmetry. More recently Ogurtsov and Burova have investigated amplitudes of longitudinal and transverse waves [16] at the boundary of an ideal elastic half-space for different values of Poisson's ratio. Theoretical seismograms can be constructed for any source distance and arbitrary pulse. Amplitudes of the longitudinal and transverse waves and their ratios were calculated for large distances.

Zvolinskiy has investigated both reflected and refracted waves produced at the boundary [17] between two elastic media. Reflected waves PP and PS, and head waves PPP, PSP, and PSS near the critical angle were discussed. Beyond the crit-

ical angle the reflected waves were substantially altered and asymptotic formulas were obtained which apply in the vicinity of the wave front. These formulas are simple enough for practical applications. It was found that amplitudes of the individual waves depend not only on the wave type, the properties of the media, and the amplitude of the incident wave, but also on the wave form. In an earlier paper Zvolinskiy [18] and a co-worker investigated head waves generated at a surface between two horizontal elastic media about a vertical line source.

Davydova [19, 20], investigated the generation and propagation of waves produced in an elastic medium by a moving source. Theoretical seismograms were computed for vertical and horizontal components of displacement, where propagation is in a thin layer within a medium of different velocity. The vertical amplitude was found to vary not only with time, but also to change in sign.

Surface Wave Theory: More than 50 Soviet papers on surface waves have been written in the last 10 years, and demonstrate considerable knowledge of surface wave theory. Soviet command of surface waves as of 1958 was summarized by V. M. Arkhangel'skaya [21] in two reports on the 1st and 2nd Extended Seminars of the Department of Seismology and Seismic Service, Institute of Earth Physics, U. S. S. R. Academy of Sciences, for the Study of Surface Waves. From the many papers given at these seminars it would appear that Soviet observations of surface waves are several years behind the United States, particularly for recording of very long-period waves, but that a considerable increase in Soviet research can be expected in this direction.

During the 1940's significant Soviet investigations on surface waves, particularly Rayleigh waves, were made by V. G. Gogoladze and N. A. Naymark. Gogoladze's main paper is a theoretical treatment of Rayleigh wave generation [22]. Naymark wrote 5 mathematical papers on the roots of period equations of elastic vibrations in layers overlying a half-space [23-26].

During the 1950's, the principal investigators of surface wave theory have been V. I. Keylis-Borok, V. M. Zvolinskiy, T. B. Yanovskaya, and G. I. Petrashen'. Surface wave investigations concerning mostly earthquake seismograms appear in this review under "Surface Waves" in "Earthquake Seismology".

Keylis-Borok's doctoral dissertation was entitled "Interfering Seismic Waves in a Multi-Layered Elastic Medium" (Geophysical Institute, 1953). He wrote several other papers on surface wave propagation in a multi-layered half-space, investigations of period equations, dispersion, attenuation of surface waves with distance traveled, and investigations of formulas describing the simultaneous arrival of Rayleigh and Love waves. The more significant papers by Keylis-Borok on surface-wave propagation are listed in the references [27-32].

Zvolinskiy has published on the mathematical theory of surface-wave propagation since 1940. Among his recent papers [21] are three presented at the 1st and 2nd Extended Seminars at the Department of Seismology and Seismic Service, Institute of Earth Physics, U. S. S. R. Academy of Sciences, for the Study of Surface Waves. At the 1st Seminar Zvolinskiy discussed basic problems in the theory of suface waves, including wave shape, amplitude decrease with distance from the boundary, roots of dispersion equations, dispersion equations for multilayered media, and possible relations between source motion and resultant surface waves. At the 2nd Seminar he discussed dispersion curves for Love waves with double layers over a half-space for a wide range of velocity contrasts, and also applied variation methods to Love wave dispersion equations.

Yanovskaya has described formulas for displacement of Rayleigh and Love waves traversing over a half-space from a stationary dipole source with a moment in two different papers [33], including one presented at the 1st Extended Seminar on Surface Waves [21]. Amplitude ratios of the Love to the horizontal component of Rayleigh waves were related to source motion. This analysis is described in this review under "Focal Parameters and Characteristics" in "Earthquake Seismology". In a theoretical paper at the 2nd Extended Seminar on Surface Waves [21], Yanovskaya described interference of waves and resultant dispersion. Dispersion curves were investigated for several different cases, including a wedge-shaped layer and multilayers, in each case overlying a heterogeneous half-space.

Petrashen' has published on interference phenomena in a two-layered medium and in three papers on interference in thin plane parallel layers [35].

Reflection and Refraction of Seismic Waves: Many Soviet papers concern reflections and refractions of seismic waves, particularly spherical waves, from multi-layered media with non-plane boundaries. Brekhovskikh has made most of the mathematical analyses of reflections and refractions, particularly of spherical waves from multi-layered media [9]. His earliest papers on reflection of spherical waves [36, 37] from plane boundaries were published in 1948. Brekhovskikh has made theoretical analyses of reflections of spherical waves from layered media, particularly for series of layers and frequencies which result in strong reflections, and for layers and frequencies which result in minimum reflections.

Berzon has written voluminously on reflection

and refraction of waves since 1942, although most of her papers are experimental rather than mathematical in content. The more recent papers by Berzon are listed in the references [38-43]. Zvolinskiy has published [17] on the reflected and head waves originating at a plane boundary between two elastic media, and the analyses include the simultaneous arrivals of reflected and head waves and the formation of interfering waves superimposed on a background of other recorded waves. Cases of different combinations of velocity contrasts of longitudinal and transverse waves in the two media were investigated. It was found that when a spherical P wave arrived at a plane boundary between two media, two reflected waves, PP and PS, two refracted waves, PP and PS, and five different head waves are produced. An approximate description was given of the transformed refracted (PS) wave and of the head waves.

Fedotov has investigated the refraction of seismic waves at curved boundaries [44], with results illustrated on dynamic travel-time curves, i. e., travel-time curves including amplitude, direction of motion, and frequency spectra of the waves, as well as arrival-times. This investigation resulted in a dissertation [45] for a Doctor of Science degree entitled "Kinematic and Dynamic Properties of Seismic Waves Refracted at Curvilinear Boundaries", May 1958.

Tsepelev in two articles treated the effects of boundaries involving velocity and density gradients on elastic wave propagation [46, 47]. Such boundaries act as reflecting surfaces, and computations for the corresponding reflection and refraction coefficients were given. Wave forms of the reflected and refracted waves were determined and shown to differ from the incident wave form. Malinovskaya has treated the dynamic characteristics of longitudinal and transverse reflected waves in the range of incidence angles [48, 49] from 10 to 80 degrees. Theoretical seismographs were constructed for these reflection cases.

Chekin has published three interesting papers on the reflection and refraction of waves. In the first, changes in the waves reflected and refracted from three plane parallel layers were computed for five different shapes of incident wave [50] and were presented graphically. In the second, approximate formulas were derived describing the spectrum of a wave front that resulted from an incident longitudinal spherical wave reflected and refracted at a plate [51]. The formulas pertaining to the spectra were found to apply for every form of incident wave, not only spherical waves. In the third paper it was shown that in non-homogeneous media waves can be reflected and refracted from zones containing a velocity gradient [52]. Corresponding coefficients of reflection and refraction were introduced.

Seismic Screening or Seismic Masking: Berzon and Yepinat'yeva published a significant paper in 1950 on the masking effect of a thin high-velocity layer on waves refracted along deeper layers [53]. This concept was not new, but these investigations formulated more clearly the effect of thin high-velocity layers. Although neither Berzon nor Yepinat'yeva have apparently published on this subject since, Petrashen' analyzed the masking problem mathematically in 1954 and proposed methods for obtaining solutions on the masking effect of thin layers [54]. Another mathematical analysis of the masking effect [55] was made by Babich and Alekseyev.

An important application of the masking effect is that refracted waves which have traveled below a thin high-velocity layer can possibly be received at the surface when the wave length is long compared to the layer thickness.

Absorption of seismic waves: Absorption of elastic waves has been investigated intensively in the U. S. S. R. As Berzon has mentioned [56], absorption used in conjunction with velocity data provides for more detailed geologic information than do only velocities and layer thicknesses. Thus, rocks and layers of similar velocities but different absorption properties can be identified and separated. The principal Soviet investigators on absorption of seismic waves have been Yu. V. Riznichenko, B. N. Ivakin, Ye. V. Karus, and A. M. Yepinat'yeva.

An early (1952) Soviet paper on absorption coefficients determined from seismic waves [57] is by Yepinat'yeva. Riznichenko has developed an equation [58] which describes amplitude changes for propagation through different media with boundary conditions that affect the behavior of the waves. This equation includes terms for distance traveled, the spreading of the wave front, and an absorption term for imperfect elasticity. The paper includes more than 25 cases of different waves, and solutions are given with characteristics of the resultant wave pattern.

Ivakin, in two publications, described mechanical and electrical models for studying absorption [59, 60] in elastic media. These models allow for elastic afterworking, for internal friction, and for residual deformation. Equations of motion corresponding to these three mechanisms were derived, where absorption is considered to be due to imperfect elasticity but not to be a function of the density of the medium. Calculations for each model also included, as a function of frequency, the velocity of propagation, absorption, and acoustic impedance. Absorption was investigated for both pulse and sinusoidal sources. The treatment is mathematical.

Karus, Vice Director of the Institute of Earth Physics, wrote his Candidate's thesis on absorption. It was entitled "Study of Absorbing Properties of Rocks by the Seismo-Acoustic Method" and was accepted by the Geophysical Institute in 1951. Karus has continued these absorption studies and has investigated absorption coefficients and logarithmic decrements of various types of rocks [61] at frequencies from 100 to 4,000 kc, using amplitude-phase measurements. Karus concluded from these measurements that rocks can be differentiated on the basis of absorption. Observational investigations on absorption have been reported by Kosminskaya [62-63], which concern correlation of amplitudes and travel-time curves of seismic phases.

Diffraction of Seismic Waves: Soviet analyses of diffracted waves have been developed as far as elsewhere. The principal Soviet investigators have been L. M. Brekhovskikh, G. I. Petrashen', T. I. Oblogina, G. A. Skuridin, and Ye. I. Gal'perin. An early Soviet investigator was S. L. Sobolev.

Brekhovskikh has investigated mathematically the diffraction of waves from an irregular surface [64]. Makarov and Petrashen' have investigated diffraction of both acoustic and electromagnetic waves by a sphere [65]. Oblogina has investigated the dynamic properties of seismic waves diffracted at the border of a vertical contact [66, 67]. She computed amplitudes and phases of individual waves both for diffracted plane waves and for three-dimensional cases, where the vertical and horizontal components of the diffracted waves were determined. The wave fronts and travel-time curves of the diffracted waves were analyzed for a vertical contact in which the wave traveled from a higher into a lower velocity medium. From mathematical analyses and numerous seismograms, travel-time curves were constructed for a vertical contact and for a wedge-shaped layer. The latter problem was studied with methods previously suggested by V. I. Smirnov and S. L. Sobolev. It was established that minima on the forward and backward travel-time curves of diffracted waves fall at the same point on the refraction profile. It was also found that the phase angle of the diffracted wave becomes reversed at that distance on the travel-time curve where the diffracted and refracted waves arrive simultaneously.

Skuridin's dissertation was on diffraction of elastic waves. This study led to two publications on the mathematical analyses of diffraction theory [68, 69], including diffraction from a fault. Formulas were presented to help distinguish diffracted from the reflected and refracted waves.

Petrashen' and co-workers have described at a Leningrad State University Symposium [70] in 1957 a series method to determine wave diffraction from angular regions. Other Soviet papers have also appeared on diffracted seismic waves. A recent summary of methods for identifying diffracted waves and differentiating them from reflected and refracted waves appears in Chapter III of the book by Puzyrev, "Interpretation of Reflection Shooting Data" (1959) [71].

Propagation in Non-Homogeneous Media: Many Soviet investigators have studied wave propagation in heterogeneous media. Among the first was V. G. Gogoladze, others include A. S. Alekseyev, B. N. Ivakin, V. M. Babich, I. S. Berzon, and L. M. Brekhovskikh. Propagation in heterogeneous media is included in Brekhovskikh's book [9].

Alekseyev's dissertation was on boundary problems of elastic wave propagation in a non-homogeneous medium (Leningrad State University, 1955). He also investigated Lamb-type problems in non-homogeneous media [72]. Babich wrote his dissertation on the equations of motion for a non-homogeneous elastic medium (Leningrad State University, 1954) and later applied Hadamard's method to plastic propagation in non-homogeneous media [73].

Ivakin has made a mathematical analysis of elastic wave propagation in heterogeneous media consisting of micro- and macro-structures [74]. The problem was approached from the theory of "four poles" used in electrical communications. An analogous theory was developed for elastic propagation along an infinite wave-guide.

Berzon has discussed amplitude and phase peculiarities of waves propagated in vertically dipping beds [75]. It was proposed that by analyzing amplitude and phase changes in waves traveling across vertically dipping beds, such wave changes may be more diagnostic of the location of the boundaries between layers than are travel-time curves alone. Using higher frequency waves increases the resolving power of this technique.

Seismic Displacements and Energies in Wave Fronts: Displacements and energies in wave fronts have been considered in several Soviet publications, including Chapters I and IV of Brekhovskikh's book, "Waves in Layered Media" [9]. He also treated mathematically the theory of displacements for spherical waves with total internal reflection [76]. In two papers, Babich analyzed mathematically the amplitudes of wave fronts [77, 78], applying the beam method of Hadamard used in geometric optics, which permitted calculations of amplitudes of non-steady elastic waves propagated in heterogeneous media. Basic formulas were derived and solutions determined. Monakhov has described displacements and polarizations of transverse seismic waves [79].

Theoretical amplitude calculations of plane stationary waves propagated across a series of high-velocity layers of finite thickness were made by Parkhomenko [80]. Part I of these investigations concerns experimental measurements; Part II, the theoretical analyses, which were in good agreement with the experimental data. Experimental investigations of energies in seismic body waves [81] at epicentral distances of more than 1,000 km have been reported by Kogan. The energy in such waves is described as a function of the distance propagated, absorption in the medium, and wave form.

Wave Motion as a Function of Source Motion: Most Soviet papers on this subject concern wave motion as a function of earthquake source displacements. These are discussed in the section on "Focal Parameters and Characteristics" under "Earthquake Seismology".

Keylis-Borok has related strains produced in the ground at some distance from a source to a point source with moment [82]. Asymmetrical faults were represented by a dipole with a moment to which a simple force was added. Seven source motions were described as combinations of point sources and simple forces. Karus and Pasechnik have described wave motion produced by a harmonic source [83].

In a significant paper, Ogurtsov presented numerical solutions from general equations of elasticity to evaluate the relative magnitudes of individual waves in the spectrum of source movements [84]. Maximum amplitudes of waves at various distances from the source were determined and shown graphically.

In two papers, Konstantinova has summarized material collected during rock bursts of April 7, 1954 in a coal mine in the Donets Basin. The first paper concerned an analysis of the mechanism of rock bursts [85], and the second treated the form of the elastic impulse produced by the bursts [86].

Laboratory Investigations

Soviet seismologists have extensive laboratory programs for investigations with ultrasonic seismic models, determinations of rock properties under varying conditions of stress and temperature, and frequency analyses of spectra on seismograms. Most of these laboratory investigations are being conducted at the Institute of Earth Physics, U. S. S. R. Academy of Sciences.

Ultrasonic Models: The Soviets have developed ultrasonic models significantly during the past 15 years. Much of this work is summarized in a 1957 article by Riznichenko [87], in which it is claimed that development of ultrasonic models in the U. S. S. R. had been carried as far as in other countries, but that the Soviets have applied seismic models to a greater number of problems.

Soviet model investigations concern direct wave and surface wave propagation in a two-dimensional half-space; simulation of earthquake foci at various depths; head wave studies; propagation in layered media involving different velocities and propagation in quasi-anisotropic layers; studies of the screening or masking effect of thin high-velocity layers on refracted waves; the reflection and diffraction of waves; and other problems [87].

The principal Soviet investigators with ultrasonic models are Yu. V. Riznichenko, B. N. Ivakin, I. S. Parkhomenko, N. V. Zvolinskiy, V. I. Keylis-Borok, F. I. Monakhov, M. P. Volarovich, and O. G. Shamina.

Riznichenko essentially developed Soviet modeling techniques, particularly two-dimensional models, and has also made propagation studies with his models. A 1951 paper [88] by Riznichenko is the earliest Soviet publication noted on seismic models. Later papers by Riznichenko and co-workers are listed in the References [89-91]. Ivakin has published papers using seismic models to investigate absorption of waves. He has also received a license for developing an apparatus for artificially producing seismic wave processes with models which represent typical geologic structures. His more significant articles are listed in the References [59, 60, 92].

Parkhomenko has used ultrasonic models to investigate head waves passing through a thin high-velocity layer [93] submerged in a fluid. Three-dimensional models were used. The form of the head wave was altered as it traversed the solid layer and the amplitudes of the diffracted wave were found to increase as the angle of incidence approached the critical angle. Quantitative figures were given for these variations. A later model study by Parkhomenko concerned waves traveling across a series of layers with increasing velocities [80].

Tectonic Models: A number of significant Soviet publications on tectonic models have been noted. M. V. Gzovskiy of the Institute of Earth Physics is the most important Soviet investigator in this field. His 1958 paper, "The Modeling Method in Tectonophysics" [94], provides a good concept of Soviet tectonic modeling methods, and includes an extensive list of Soviet references.

Tectonic modeling is of secondary interest in seismology and is not discussed further in this review.

Rock Properties: There are many Soviet publications on investigations of rock properties. Of

interest here are those on laboratory determinations of elastic constants, especially at elevated pressures and temperatures. Several papers concerned determinations of stresses in mine pillars using ultrasonic velocity measurements. Rock mechanics is treated in a book by L. A. Schreiner [95]. M. V. Volarovich and co-workers have made ultrasonic velocity measurements [96] of coal at confining pressures up to 1,000 kg/cm^2, and measurements of wave velocities in rock specimens [97] at pressures up to 5,000 kg/cm^2. Silayeva has investigated methods for determining elastic properties of rocks under confining pressures [98] and has obtained experimental data with ultrasonic techniques on the elastic properties of rocks and the absorption of elastic waves in rock specimens. The elastic constants were found to increase and absorption decrease as confining pressures were increased up to 100 kg/cm^2. The technique of measurement simulated seismic field procedures, in which amplitudes were recorded along a profile line. These investigations by Volarovich and Silayeva are significant, but it is noted that they did not include as high pressures as have been used by P. W. Bridgman, D. T. Griggs, and others.

Riznichenko and co-workers have published papers on ultrasonic methods for measuring velocity of propagation in rocks under strain, including determination of rock tension from ultrasonic velocities [99], and the effect of uniaxial compression on the velocity of propagation in rocks [100, 101].

Laboratory analyses of frequency spectra: Significant Soviet papers have appeared on frequency analyses of seismograms. Spectral analyses provede another factor that may help differentiate types of seismic waves.

Berzon has pointed out that frequency analyses of seismic waves have been made for a number of years [56] at the All-Union Scientific Research Institute of Prospecting Geophysics, where an apparatus was constructed some years ago and data have been obtained since then on spectral compositions of reflected and refracted waves. More sensitive instruments for spectral analyses were built in 1954-1955 at the Institute of Earth Physics, U. S. S. R. Academy of Sciences. Some of these spectral analyses included frequency investigations of various waves traveling through thinly stratified media.

Shamina [102] and Slutskovskiy [103] both wrote their Candidate's dissertations on frequency analyses of seismic waves. Voyutskiy and Slutskovskiy developed frequency analyses techniques for seismic investigations prior to 1952 [104].

Bereza and co-workers have described instrumentation for frequency analyses of seismic wave which consists of 24 sharply-tuned slightly-damped galvanometers, each with a different resonant frequency [105]. Each galvanometer recorded the amplitudes of the frequency components present to which it was tuned. In a later paper, Bereza described new instrumentation which consists of seismographs, broad-band amplifiers, and recording elements taken primarily from existing field instrumentation. A two-channel apparatus was used for recording seismic waves in the field. It was claimed that seismic reproduction with this apparatus resulted in negligible frequency distortion.

Khudzinskiy and Melamud have given a detailed description of instrumentation that automatically recorded wave spectra in the range of 10 to 250 cps, which can be used either in the field or in the laboratory [107]. Recording seismographs with variable band-widths will permit frequency analyses with conventional seismic equipment, requiring only minor modifications. Recently improved amplifiers with wider pass-bands permit even more sensitive frequency analyses [108]. Illustrations of frequency spectra of various types of waves were given by Khudzinskiy and Melamud [107], including records from single seismometers, seismometer arrays, waves recorded by different natural frequency seismometers, and recordings in bore holes.

In a series of articles, Gol'tsman has discussed frequency analyses of seismic waves [109-112], including graphical methods, linear filtering systems, and inverse frequency characteristics of filtered signals. Another paper, by Gryn, concerns mathematical analyses of spectra for one type of impulse [113].

Earthquake Seismology

General Statement

Since the destructive Ashkhabad earthquake of October 6, 1948, Soviet earthquake seismology has been expanding rapidly. By 1957, 70 permanent earthquake stations and a total of 94 stations were reported in operation. By 1959, there were still 70 permanent stations (40 belonging to the Institute of Earth Physics and 30 to the regional seismological organizations), but additional recordings were being made at various geophysical observatories and by field expeditions. A number of new seismograph stations have been installed or are planned for installation during the next few years [114]: 37 in Siberia, 2 in Antarctica, and more elsewhere.

Solov'yev has reported that at the March, 1959, meeting of the Council on Seismology of the U. S. S. R. Academy of Sciences, a Single Seismic Service [114] for the U. S. S. R. (YeSS) was discussed and accepted. Henceforth, all earthquake stations will operate under the regulations of the new Single Seismic Service, under

the supervision of the Council on Seismology.

A summary of Soviet earthquake seismology appeared in a 1957 article by Savarenskiy [115], and a statement on the future program was included in the article by Solov'yev [114]. An excellent book on Soviet earthquake seismology is that by Savarenskiy and Kirnos [116], "Elements of Seismology and Seismometry".

The 1957 "Atlas of the Seismic Nature of the U. S. S. R." has been the most significant publication of the Soviet Seismic Service. The Atlas is a collection of works of seismologists from the U. S. S. R. Academy of Sciences and from Union Republic Academies. It includes catalogs, charts, and records approximately 10,000 earthquake epicenters; it also includes discussions on the cause and mechanism of earthquakes and provides the basic data for seismic zoning in the U. S. S. R.

Data on the permanent Soviet Seismograph stations have appeared in the published literature, they include station name, geographic location, and types of instruments installed. Descriptions of the seismographs used have also been published. The majority of the Soviet seismograph stations record with the broad-band vertical SVK and horizontal SGK Kirnos instruments. These instruments have been modified to the vertical SVK-M and horizontal SGK-M instruments, which have considerably higher magnifications that are peaked at periods of approximately one second. Several of these seismographs have been used with much success. Soviet seismographs commonly used for recording local earthquakes are the vertical VSKh and horizontal GSKh Kharin instruments. These have high peak magnifications over a relatively narrow short-period range (0.15 to 0.35 seconds).

Earthquake Catalogs and Records: Numerous Soviet articles have been published on U. S. S. R. earthquakes, particularly in the Soveta po Seysmologii, AN, SSSR and in bulletins of the various Soviet Seismic Stations. The 1957 "Atlas of the Seismic Nature of the U. S. S. R." is an outcome of data from these publications.

Specific Earthquakes and Seismicities of Particular Areas: Many articles have described particular Soviet earthquakes and seismicities of the more active regions, particularly Southern Russia, Central Asia, and Eastern Siberia. Numerous papers have also described the earthquakes which have occurred within a region. It is beyond the scope of this report to discuss individual earthquakes or seismicities of areas.

Earthquake Investigation Expeditions: Numerous Soviet earthquake expeditions have been organized to make investigations in particular areas, specifically the Caucasus, Turkmenia, Tadzhikistan, northern Tien-Shan, Kazakhstan, Kuril-Kamchatka, and Antarctica. Most of these expeditions have been sponsored by the Academies of Sciences of the U. S. S. R. and the Union Republics. Some expeditions were large and have been in operation for a number of years; others were smaller and shorter lived.

Only the more prominent expeditions are here mentioned. The Garm Geophysical Expedition is probably the most extensive. It operated from 1942-1949 and completed construction of special earthquake stations at Stalinabad and at Obi-Garm. It also organized temporary seismic stations within a radius of 100 km of these main stations to record foreshocks for earthquake prediction studies.

The Ashkhabad Expedition was organized in 1949 to record aftershocks of the destructive 1948 Ashkhabad earthquake. Five temporary stations were used by this expedition. The Aral-Caspian expedition was organized in 1951 to study earthquakes along the Turkmen Canal and to determine seismic zoning in the vicinity of the canal. The second Turkmen Expedition of the Geophysical Institute, U. S. S. R. Academy of Sciences, made seismic measurements near Ashkhabad in 1953 with VEGIK and Kharin seismographs. The VEGIK seismographs were used for engineering studies and the Kharin for earthquake recording [118].

The Shemakha Seismic Expedition [119] of 1953 studied azimuths and emergence angles of arriving waves as a function of dip angles of strata traversed. The ray azimuths were noted to coincide with the source direction when strata between station and epicenter were horizontal, but not when dipping. The Apsheron Seismic Expedition [120] of 1957-1960 investigated the seismicity of the Apsheron Peninsula and utilized six small seismic installations. The Tadzhik Seismological Expedition of 1955 and 1956, sponsored by the Geophysical Institute, U. S. S. R. Academy of Sciences, and the Tadzhik S. S. R. Academy of Sciences, investigated improved methods for locating epicenters in the Tadzhik area. Among International Geophysical Year expeditions, the Soviet Antarctic Expedition established seismic stations at the "Mirnyy" and "Oazis" settlements [115].

Earthquake Mechanisms

Numerous Soviet publications concern the mechanism of earthquake sources. Beloussov and Gzovskiy [121] have contended that the tectonic displacements are produced by vertical movements in the crust which are particularly pronounced along the borders between oceanic and continental areas. They maintained that slow deformations produce plastic flow without consequent earthquakes, whereas rapid deformations result in earthquakes.

The most quantitative Soviet analyses of earthquake mechanisms have been made by Keylis-Borok. In a number of papers he described methods for determining the strike and dip of a fault plane at earthquake foci from the first motions of P and S waves and ratio of the amplitude of P to the amplitude of S. These are discussed in the section on "Focal Parameters and Characteristics". Studies made at the Geophysical Institute, U.S.S.R. Academy of Sciences, since 1948 on earthquake mechanisms [122] and resultant wave propagation from various types of faults have been described by Gotsadze and co-workers.

Keylis-Borok and Malinovskaya have investigated fault motions producing earthquakes in northern Tien-Shan [123]. Weak earthquakes in the Tien-Shan area were found to be associated with faults that strike nearly perpendicularly to the main fault direction.

The mechanism associated with deep earthquakes has been described in several papers. It was proposed by Egyed [124] that the earth is expanding its diameter at a rate of about 1 mm per year due to physical changes in its interior and that this expansion produces earthquakes along zones in which the accumulated stress exceeds the strength of the crust. The effect of such expension would be to produce zones of relative tension. Kogan wrote his Candidate's dissertation [125] on the dynamic parameters associated with deep earthquake foci. His working hypothesis was a uniform subcrustal flow which produced tectonic movements and resulted in the observed geosynclinal and platform structures [126].

Relation of Earthquakes to Geology: More than 30 papers were noted that relate geology to earthquakes. Most of these papers, however, concern descriptions of geology in areas of high seismicity.

Razanov correlated the detailed geology with the great Ashkhabad earthquake of 1948. He analyzed this quake, and others in the area which had been described by Rustanovich, by relating earthquake foci to regional geologic features [127]. Most of these shocks originated in the deeper sedimentary layers in the Kopet-Dagh foredeep (Turkmen S. S. R.) and within the upper portions of the underlying basement rocks, ranging in depth from 3 to 12 km. It was concluded that the main Ashkhabad earthquake was related to the most recent tectonic movements, which have resulted in an uplift in the southwest portion of the Ashkhabad area. The Ashkhabad earthquake was found to have occurred along a hinge-line between recent subsidence and uplift.

Gzovskiy wrote a significant paper on the relation between seismicity and geology [128], which was an outcome of a 1955 program of study at the Geophysical Institute, U. S. S. R. Academy of Sciences, to formulate geologic criteria as an aid to forecasting earthquakes. Gzovskiy emphasized the need for knowing regional stresses and stress accumulations in the earth. He recommended that model studies should be made concurrently with field investigations. This paper includes many references, mostly to Soviet authors, pertaining to the relation between earthquake mechanisms and geologic features.

Savarenskiy and Nenilina [129] attempted to allow for geological features, particularly boundaries between major features, in locating earthquake foci. The procedure described for eliminating the effect of geological heterogeneities to permit more precise focal locations includes first determining focal positions by conventional methods, and then recalculating them for assumed geologic structures. Several examples were given.

Earthquakes and Ground Tilt or Movement: Some Soviet analyses have been made on the relation between ground tilt and earthquakes. Bonchkovskiy has described sizable ground tilts at large epicentral distances both preceding and accompanying large earthquakes [130]. The large 1951 earthquake on Tiawan resulted in a change of motion on inclinometers in England in a mine at a depth of 116 meters and the inclinometers remained at a new level after the quake. Inclinometers in Japan also recorded significant changes of slope during this earthquake. It was mentioned that deformations have long been recorded in Japan which both preceded (by as much as 18 months) and accompanied strong local earthquakes.

Two mutually perpendicular quartz torsional deformographs were installed at the Yalta Station [130] in 1956. These deformographs showed irregular breaks 18 hours prior to the March 9, 1957 earthquake in the Aleutian Islands. After the shock there was a change in sign on the deformograph records. Bonchkovskiy concluded that further study is needed to determine the mechanism producing the tilt and whether ground tilts can be used as criteria in earthquake warnings. The implication that stresses can be transmitted throughout most of the crust of the earth is consistent with 1951 conclusions by H. Benioff in the United States.

Ostrovskiy has reported on slow movements of the earth's crust in which very low-frequency waves arrive from a stong shock prior to the initial P wave [131]. Gurevich has also studied the nature of slow displacements associated with earthquakes. He proposed instrumentation which would measure slow ground displacements prior to earthquakes [132] that could be used as possible forerunners of the actual shocks.

Causes of Earthquakes: A number of Soviet

papers concern the relation between tectonic faulting and strains in the earth's crust and upper mantle, although no other significant theories were noted on causes or earthquakes. Gzovskiy has written several papers on mechanisms associated with tectonic faults [133] and has proposed modeling tectonic stress fields and consequent ruptures [134].

Little has appeared in Soviet literature on particular stress distributions in the ground that result in observed source motions. On the other hand, considerable emphasis has been placed upon defining displacements at the source from first motions of body waves and from analyses of surface waves [135].

Earthquake Aftershocks: Soviet investigations of aftershocks, as from the 1948 Ashkhabad earthquake, are made routinely, but few articles concern analyses of aftershock data. The 1957 "Atlas of the Seismic Nature of the U. S. S. R." contains pertinent data.

Earthquake Periodicity: Few Soviet papers concerned periodicities of earthquakes. Pertinent data may appear in the 1957 Atlas. One paper by Kirillova relates earthquake periodicity with vertical crustal movements [136], as evidenced by fluctuations of the Caspian Sea. In view of the Soviet interest in earthquake prediction, a larger number of Soviet papers on earthquake periodicity is to be expected.

Earthquake Prediction: Earthquake prediction has been a field of major Soviet investigation. Soviet concern with prediction, as of 1955, was summarized by Gamburtsev [137] at a Conference of Russian Seismologists on Methods of Forecasting Earthquakes. The object of forecasting was to predict the approximate time, location, and maximum intensity of an earthquake. Suggested directions of observation included measurements of slow movements on the earth's surface, recording foreshocks, and determining possible changes in seismic velocities in deeper strata. It was held that destructive earthquakes occur along major active faults, and that it is for earthquakes along such faults predictions should be directed.

In 1955, one of the major programs of the Geophysical Institute, U. S. S. R. Academy of Sciences, was to investigate all possibilities for predicting earthquakes, including geologic criteria. At a 1954 meeting of the Geophysical Institute, 14 papers were presented on earthquake prediction which have been published [138] in the Transactions of the Institute. Many senior Soviet seismologists participated in this prediction program. These investigations concerned correlating earthquakes with local geologic structure, geomorphology, preliminary ground tilt, both high-frequency and low-frequency forerunner waves, variations in the earth's magnetic field, variations in atmospheric electric potential, and period of the moon.

Interpretation of Earthquake Seismograms

Many Soviet papers pertain to interpretation of seismograms from teleseisms, particularly those from shallow shocks. Most authors on seismogram investigations have been affiliated with the various Soviet seismological stations or the Moscow headquarters of the Institute of Earth Physics.

Travel-Time Curves of Earthquake Seismograms: N. V. Kondorskaya, who wrote her Candidate's dissertation on interpretation of travel-time curves (Geophysical Institute, U. S. S. R. Academy of Sciences, 1954), appears to be the major Soviet contributor to this field. She has published papers on regional peculiarities of travel-time curves [139] and determined corrections for the Jeffreys-Bullen travel-time curves for recordings made in the Far East, Central Asia, and the Caucasus. She has found that statistically determined corrections resulted in more accurate epicentral locations. Kondorskaya published further corrections to the Jeffreys-Bullen travel-time [140] tables in 1957. Other authors have constructed travel-time curves for Czechoslovakia, the Caucasus, Central Asia, and other areas.

Epicentral Location and Ray Azimuth: Numerous Soviet papers concern methods for determining epicentral locations and some on ray azimuths and emergence angles. Other sources list epicenters of various areas, particularly the "Atlas of the Seismic Nature of the U. S. S. R." (1957) and an epicentral map of northern Tien-Shan [141].

Significant papers concern improved methods of determining epicentral locations. Tvaltvadze and Kartsivadze have used new data to determine the distribution of epicenters and foci of earthquakes in the Caucasus [142]. Corrections were made to travel-time curves for the effect of sedimentary layers, which may be as thick as the granitic layers in this region. Equations for the corrections were developed. Riznichenko investigated improvements in epicentral locations by comparing observed data with theoretical data for assumed velocities and layering in the area [143]. Allowances for geologic variations were found to improve epicentral locations. The procedure was tested on many earthquakes recorded in 1955 and 1956 by the Tadzhik Seismological Expedition. Numerous checks have shown that this method is more accurate than conventional methods for epicentral location.

Sultanova investigated errors in hypocentral locations [144] of local earthquakes and showed that accurate locations require corrections for local velocity variations. Corrections for geologic variations did change hypocentral

depths, but not epicentral locations. Glivenko has also studied accuracies for determining earthquake hypocenters [145].

Kolosenko has investigated the effect of the ellipticity of the earth for accurate determinations of epicentral distances [146]. He concluded that ellipticity corrections permit more accurate epicentral locations of distant earthquakes than can be obtained with the Jeffreys-Bullen tables.

Numerous Soviet papers concerned determination of azimuth and emergence angles of seismic waves from nearby shocks. Most of these were written since 1941 by Savarenskiy and co-workers. Some of the important papers are listed in the References [147-152].

A new technique for determining seismic ray paths, the azimuthal method, has been developed in the U. S. S. R. This technique is summarized in the book by Ye. I. Gal'perin [153], "Azimuthal Method of Seismic Observations" (1955). The method consists of placing a number of seismometers in a closely spaced circular array, such that the direction of maximum amplitude of the incoming wave can be determined as well as amplitude components in other directions. One procedure consists of placing 8 seismometers in a small circle, each tilted 45 degrees to the vertical and oriented horizontally 45 degrees to its adjacent seismometers. Such seismometer arrays have been used to improve locations of earthquake epicenters in areas where shocks were too small to be recored at other stations. The method is no more accurate than conventional location of epicenters involving triangulation from 3 or more stations. The instrumentation, interpretation procedures, and reliability of the azimuthal method are described by Gal'perin [153].

From 1951 to 1953 the azimuthal apparatus was used to record earthquakes [154] in Turkmenia, near Alma Station, and in Garm Oblast. Vector displacements of incoming waves were calculated from sets of 8 seismographs at a station, and approximately 100 earthquakes were used for these azimuthal studies. The interpretation procedure is described in the paper.

Long-Period Waves on Seismograms: Surface wave theory was discussed in the section on "Wave Propagation". Analyses of long-period waves on seismograms are included in the following paragraphs.

Soviet ability to interpret surface wave data on seismograms is well summarized in two reports by V. M. Arkhangel'skaya on the 1st and 2nd Extended Seminars of the Institute of Earth Physics on Surface Waves [21]. Significant papers were presented at the Seminars on surface waves recorded on seismograms.

A most significant paper presented at the seminars was by Yanovskaya [21] on an analysis of surface waves to determine the direction of wave emission from earthquake foci. This method was analyzed in an earlier paper [33] and it is discussed in this review under "Focal Parameters and Characteristics", in "Earthquake Seismology".

Arkhangel'skaya reported at the seminars [21] on experimental studies of surface waves to define their characteristics and investigate the possible existence of new types of surface waves. She described determinations of group and phase velocities and resultant dispersion curves for surface waves from which average thicknesses of the earth's crust could be obtained. Dispersion curves were investigated of Love and Rayleigh waves from numerous earthquakes recorded on seismograms at various Soviet stations.

Variations in periods of surface waves [155] with epicentral distance have been investigated by Solov'yev and Shebalin. Recordings with the wide-band SVK and SGK Kirnos seismographs have led to the conclusion that the maximum period of a surface wave increased as the cube root of epicentral distance, up to 17,000 km distances (farthest distance recorded). Such a period variation may be significant in differentiating explosions from earthquakes.

Determinations of epicentral locations from surface waves [156] had been made by Arkhangel'skaya before 1957. Epicentral distances for distant earthquakes were calculated from arrival-time differences between Love and P waves and between Rayleigh and P waves. This approach cannot be used for local shocks because of the nearly simultaneous arrival of the Love and Rayleigh waves. Epicenters of local shocks were determined from L-P times, where L is the surface wave time. A new wave L_x was noted, which has a period of 7 to 10 seconds and appears to be propagated in the upper layer of the earth's crust. At the 1st Seminar for the Study of Surface Waves, Savarenskiy and Ragimov discussed epicentral azimuths of Rayleigh waves [21] as calculated from seismograms at 3 adjacent stations. Several papers at the seminar also concerned surface waves generated in local earthquakes.

Although the Soviets have developed surface wave theory significantly, participants at both seminars concluded that much remains to be done on surface wave development. Greatest effort, it was stated, should be directed toward interpretation of observed surface waves, becoming familiar with surface-wave investigations in other countries, and developing long-period seismographs.

Microseisms: Considerable Soviet research has been done on microseisms and their relation

to storms in oceanic regions and in the larger inland seas. Monakhov [157] and co-workers have recently studied the structure of microseisms and their relations to storms at sea. The character of particle motion of microseismic waves originating in both the Black Sea and the North Atlantic Ocean were investigated. The majority of the microseisms were complex in character. Love waves were absent in almost every case. Rayleigh waves made up about 5 percent of the microseisms from the Black Sea and 15 percent of those from the North Atlantic. The oscillation planes of the Rayleigh waves were usually oriented toward the origin of the microseisms.

Savarenskiy and co-workers related microseismic activity to strong winds in the Lake Issyk-Kul' region [158]. The results were based on data collected over a three-year period. The microseismic periods were found to be related to wind velocities on the lake.

Veshnyakov [159] investigated errors in microseismic azimuthal determinations from recordings at tripartite networks. It was proposed that azimuth errors can be reduced if the distance in the tripartite station network is increased to triangles 6 to 7 km on a side. Rykunov and Prosvirin [160] have analyzed microseismic azimuths distorted by the propagating media. The effect of refraction along oceanic and continental crusts was investigated, using phase velocity dispersion curves. It was found that variations in the depths of refracting layers beneath the ocean do effect azimuths of microseisms. A technique was proposed for elimination of azimuthal distortion.

Tsunami: In 1958, the U. S. S. R. initiated a tsunami (seismic sea wave) warning service. Papers on tsunami,* and the need for a warning service, were presented in 1957 at the (first) Conference on the Problem of Tsunami and the Seismicity of The Far East, held at Novo-Aleksandrovsk [161] (Yuzhno-Sakhalinsk), sponsored by the Seismologic Council and the Sakhalin Institute of the Scientific Studies, both of the U. S. S. R. Academy of Sciences. At the Conference Savarenskiy discussed the need for a tsunami service in the U. S. S. R. and also reviewed tsunami services in the United States and Japan. Other papers concerned theoretical calculations of wave heights anticipated at various coastal locations from strong shocks at sea, including a comparison of estimates with observed heights. Papers also included the effect of coastal relief and epicentral distance upon tsunami heights. It was recommended at the Conference that installations be constructed for automatic means of warning populations of oncoming tsunami.

Previous Soviet work on tsunami was noted in papers by Brekhovskikh and Savarenskiy. Brekhovskikh pointed out that tsunami warning is possible because the tsunami velocity is 600 to 700 km per hour, while the velocity of sound in water is about 5, 500 km per hour. An effective waveguide in the oceans exists at a depth of 1, 200 to 1, 400 meters, where attenuation is small; therefore tsunami can be detected over considerable distances [162]. Savarenskiy mentioned that tsunami are caused by abrupt changes in the volume in an ocean basin and are thus caused by tectonic earthquakes [163] with shallow foci. Warnings of approaching tsunami can be obtained by acoustic waves traveling through the water because of the large differences in the velocity of tsunami and sound in water. The position and direction of propagation of tsunami can be calculated from shallow earthquake epicenters or from an advancing tsunami recorded at least by three stations.

Source and Focal Conditions

Soviet seismologists have been investigating focal conditions by analyses of seismograms and of earth-tilts prior to and during an earthquake. The prominent investigators are V. I. Keylis-Borok, S. D. Kogan, T. B. Yanovskaya, S. L. Solov'yev, and N. V. Shebalin.

Focal Parameters and Characteristics: Since 1950 Soviet investigators have made seismogram analyses of motions at the focus from the direction of first motion of body waves, the ratio of amplitude of P to the amplitude of S, and from amplitudes of surface waves. Keylis-Borok has been the principal contributor using body waves and Yanovskaya using surface waves.

Keylis-Borok [164] published his first paper on the dynamic parameters of a focus in 1950 and presented a graphical determination for displacements at the foci in another publication [165]. This was followed in 1957 with a theoretical paper on the relation between waves propagated and type of fault displacement [166].

An excellent Soviet publication on various investigations of the mechanisms of earthquakes, based primarily upon the techniques of Keylis-Borok, appears in a separate issue of the Transactions [167] of the Geophysical Institute (U.S.S.R. Academy of Sciences). Papers in this issue are by V. I. Keylis-Borok, S. D. Kogan, O. D. Gotsadze, T. I. Kakhtikova, and L. N. Malinovskaya and include determinations of earthquake displacements in some of the Soviet seismically active areas.

Keylis-Borok also described his methods in the Italian journal [168], Anali Geofisica. An ellipsoid of rotation was taken as a model of an

*The singular and plural forms of the Japanese term tsunami are identical -- M. R.

earthquake focus and equations were developed which relate the fault plane area and fault displacement in terms of energy released, the shear modulus, and the mean stress acting prior to the earthquake. It was contended that numerous weak earthquakes may play an important role in the formation of and movements along large faults, although the amount of seismic energy released in the weak earthquakes was stated to be negligible. Keylis-Borok's methods have also been summarized in English [169].

Significant investigations on the use of surface waves for determining directions of earthquake movements have been published by Yanovskaya [33] and summarized in a paper given at the Seminar of the Department of Seismology and Seismic Service of the Institute of Earth Physics for the Study of Surface Waves [21]. The analysis consists of using amplitude ratios of Love and the horizontal component of Rayleigh waves for the same period. Periods of 20 to 24 seconds were used and corresponding amplitude ratios were plotted as a function of epicentral azimuth for waves received at different stations from the same shock. It was concluded that at the intersection of the curve with the abscissa, the azimuth at which no Love wave arrives, the abscissa value is the same or 180^{o} out of phase with the direction of the motion. Applications of this method to several Soviet earthquakes were claimed to have been in good agreement with independent analyses of first motions of body waves. Yanovskaya [21] gave another paper at the following year's seminar, but it was noted that she did not continue with the analysis of source motions from surface waves on seismograms.

S. D. Kogan's Candidate's dissertation (Geophysics Institute, 1953) was on the investigation of the dynamic parameters of deep focus earthquakes. This and his subsequent investigations on deep focus mechanisms have been published [126, 170, 171]. Various types of dynamic sources at the foci were investigated. The earlier papers considered simple sources. The most significant paper [171] discussed the effect of the sum of separate simple sources, including: a simple force plus a dipole producing a moment, a simple force plus a dipole without a moment, a dipole plus a moment, a dipole without a moment, and superposition of two dipoles with a moment. Analytical expressions were derived for the components of displacement, but graphical methods were used for the combined source motions.

Magnitude, Intensity, and Energy of Earthquakes: Several Soviet papers have related magnitude, intensity, and energy of earthquakes. Shebalin studied the relation between intensity and magnitude of earthquakes with respect to focal depths for a series of shocks [172], from which he concluded that the Gutenberg and Richter equations relating energy and magnitude require modification for shocks at depths below 20 km. Solov'yev and Shebalin have developed empirical equations relating earthquake magnitude to amplitudes and periods of surface waves [155] on seismograms. Other authors have published on the classification of earthquakes according to energy at the focus [173, 174].

Seismicity and Seismic Zoning in the Soviet Union

Approximately 200 Soviet papers on seismicity and seismic zoning in various parts of the U. S. S. R. have been noted. The main contributors to this subject have been Ye. F. Savarenskiy, G. P. Gorshkov, N. V. Gzovskiy, N. V. Krestnikov, I. L. Nersesov, N. V. Kondorskaya, S. S. Andreyev, Ye. A. Rozova, N. A. Vvedenskaya, and V. V. Beloussov.

Sabarenskiy has written numerous papers on seismicities of different portions of the U. S. S. R. Under his direction [175] the 1957 "Atlas of the Seismic Nature of the U. S. S. R." was prepared. Earthquakes were classified in the atlas by accuracy of epicentral location and by seismic regions. These include the Carpathians, Crimea, Caucasus, Kopet-Dagh, Central Asia, Altay, Baykal, Far Eastern, and the Arctic areas.

A general survey of the seismicity [176] of the U. S. S. R. was published by Gorshkov. This paper also mentioned that tectonic movements are the main cause of earthquakes.

Most seismicity papers pertained to investigations of particular localities. Some of the papers relate seismicity to tectonics, to geomorphology, to energy characteristics at the source, to periodicities of earthquakes, to chronology of earthquakes, and related factors.

Soviet seismologists have placed much emphasis on the seismotectonic method of outlining seismic areas, wherein seismic activity is correlated to tectonic activity. A description of the seismotectonic method was published in 1957 by Krestnikov [177]. A comparison of the tectonics and seismicity [178] in the very active Garm region of Tadzhik was described by Gzovskiy and co-workers, who reviewed the history of the tectonic movements and made a quantitative comparison of the tectonics and seismicity of the Garm region. They presented new interpretations of the tectonics of the Garm region, which joins the Pamir and Tien-Shan regions.

The highest seismicity in the U. S. S. R. is in the Kuril-Kamchatka region of the Far East. Kondorskaya and Postolenko have described the seismic activity of this region [179] from 1954 to 1956. The second highest seismicity occurs in the Tadzhik S. S. R. Bune [180] has written

papers on this area and I. Ye. Gubin, Ye. Ya. Rantsman, I. P. Pasechnik are among many others who have investigated the seismicity of this region. The largest number of seismicity papers have been written on the Caucasus. Of many publishing on this area, Ye. I. Byus, I. V. Kirillova, A. A. Sorskiy, and S. S. Andreyev are prominent. Andreyev wrote his Candidate's dissertation on the depth structure and seismicity of the Turkmen region.

Seismicities of Central Asia were described by Ye. A. Rozova, S. V. Puchkov, D. N. Kazanli, N. A. Vvedenskaya, and A. A. Vogel. The latter two published an epicentral map of Northern Tien-Shan [141]. Seismicities of other areas have also been described in the Soviet Literature, such as the Black Sea depression, the Crimea, the Kirgiz S. S. R., the Ural Mountains, Azerbaydzhan, the Arctic, and also areas outside of the Soviet Union, such as the Balkans and Scandinavia.

Seismic zoning: Seismic zoning is a concept developed in the U. S. S. R. that refers to assigning quantitative figures to areas signifying the intensity and frequencies of earthquakes occurring within a region. The purpose of seismic zoning is to aid in prediction of occurrence and the intensity of an earthquake, and in the preparation of building codes.

The fundamentals of the methods of seismic zoning have been summarized in a recent article by Puchkov [181], who included a short history of seismic zoning in the U. S. S. R. The first seismic zone maps were published in 1933 and showed possible areas of future earthquakes above a certain intensity in Turkmenia. In 1947 G. P. Gorshkov published more seismic zone maps of Turkmenia. In 1949 S. V. Medvedev constructed a seismic zone map for the Moldavian S. S. R. Also in 1949, Gubin suggested that seismic zoning maps should be based on past [182] and anticipated earthquake activity. In 1954, V. V. Beloussov proposed basing seismic zoning on an analysis of the tectonic history of an area [183].

The official Soviet map of seismic zoning was published in 1956 under the direction of S. V. Medvedev and included seismic zoning of the entire Soviet Union. The 1957 "Atlas of the Seismic Nature of the U. S. S. R." included seismic zoning maps of the entire country. For these latter maps, a new scale of earthquake magnitude [175] was introduced, base upon amplitudes and periods on recorded seismograms using the Gutenberg-Richter scale.

In addition to maps of the U. S. S. R., Soviet seismologists have also helped develop zoning maps of Hungary, Yugoslavia, China, and other areas. Recently a map on seismic zoning of China [184] was published, which includes listings of about 10,000 earthquakes and includes two maps: one of isoseismic lines and the other of seismic regionalization.

Earthquake Resistance Investigations

Many Soviet investigations on requirements for earthquake-proof structures have been documented, including a 1958 issue and a 1959 issue of the Transactions [185, 186] of the Institute of Earth Physics. Numerous papers pertain to relative earthquake damage to buildings located on hard rock and on soft rock. It was established that a shock with an intensity of 12 (scale used not indicated) for structures on soft rocks may have an intensity of no more than 8 for structures on bedrock. Rarely, it is claimed, do shocks exceed an intensity of 8 on bedrock. Pertinent articles are listed in the References [187-189].

A new book by A. G. Nazarov [190], "Engineering Analysis of Seismic Forces," described new methods for determining seismic forces with seismographs. Equations of ground motion for multi-channel seismometer recording were integrated from which structural behavior during an earthquake was determined. The seismographs used, mostly strong-motion types, were described in the book. Earthquake intensity was determined from amplitudes and accelerations. The book includes a short survey of seismic instrumentation.

Nazarov [191] also published an analysis of vibrations and stresses produced in structures by earthquakes. Allowance was made for frictional energy losses in structural vibrations. The analysis showed that stresses and deformations in a building are not in phase. Deformation was measured by the seismographs. Stresses were calculated, first from the deformations, and then modified to include frictional resistance. Stresses can thus be determined in a structure from the amplitude and frequency spectra of a recorded shock.

Karapetyan has calculated stresses to which a structure is exposed during an earthquake, using the wave form of the ground vibrations [192]. This procedure was illustrated, using a 1931 earthquake near Tokyo. From equations developed maximum accelerations of the structure were computed and calculations given. Medvedev reported the effect of seismic activity on building structures in several papers [193, 194].

The effect of explosions on manmade structures was investigated in the early 1940's, by M. A. Sadovskiy [195], who summarized his results in a small booklet.

Earthquake-proof construction has been treated in many Soviet papers. Of interest are papers by Kukebayev [196], which concerns structures in the Kazakh S. S. R. region, by

Biryukov [197], which describes design experiences in building construction at Alma Ata, and by Bukhovstov [198], which concerns stress analyses of buildings.

Composition of the Earth from Seismology

A summary of the origin and composition of the earth [199] was published by Levin in 1957.

Crust of the Earth: Several Soviet papers pertain to techniques for determining crustal structures and of descriptions of regional crustal features. Most papers, however, pertained to descriptions of the crust in particular areas.

A summary of crustal cross sections as they exist in various parts of the earth has been included in the book by Savarenskiy and Kirnos [116], "Elements of Seismology and Seismometry". Most of the crustal sections illustrated were based on seismic explosion data. A recent investigation of the earth's crust in Central Asia, using explosion seismic methods, has been published by Ulomov [200].

S. S. Andreyev [201] has proposed use of the transferred wave PS from earthquakes for studying crustal structure. He has claimed that use of these waves provides a method which is independent of the origin time of a shock and is not sensitive to errors in epicentral location.

Numerous papers refer to the crustal structure of the Caucasus. Karapetyan wrote his Candidate's dissertation (1953) on the structure of the earth's crust in the Caucasus [202]. Treskov has written several papers on the earth's crust in the Georgian area, investigating crustal thickness from differences in arrival-time of various waves from a deep focus earthquake [203].

Other papers on crustal structure from earthquake data were noted, but are beyond the scope of this report. Many of these pertain to the Kuril-Kamchatka depression, the Russian Platform, structures of the Trans-Caspian and the Tien-Shan areas, and the transition zone from the Asiatic continent to the Pacific Ocean.

The Earth's Mantle: Few Soviet papers were noted to concern the mantle of the earth. One significant paper is by Shirokova, which discussed longitudinal waves from deep earthquakes [204] in the Hindu Kush Mountains. It was determined that the low-velocity layer in the upper mantle extends to a depth of at least 200 km. The boundaries of this low-velocity layer were claimed to be relatively sharp and the change in velocity at the upper boundary was about 10 percent and that at the lower boundary was somewhat less than 10 percent. These results are of special interest as considerable work has been done on this low-velocity layer in the United States.

Bugayevskiy proposed to use derivatives of travel-time curves instead of direct travel-time curves as a method for determining composition in the mantle [205]. Average values of the derivatives of the travel-time curves were used as an indication of composition. Vvedenskaya and Balakina have shown that ratios of longitudinal to transverse waves, recorded at numerous Soviet stations from 18 earthquakes in the eastern hemisphere, verify the previously identified discontinuities within the mantle [206]. Magnitskiy discussed the variation of the elastic constants in the 400-900 km range in which a transition of materials is thought to occur [207].

The Earth's Core: Few Soviet papers were found to concern the earth's core. One by Rykunov, on the decrease of amplitude of P waves in the earth's shadow zone at epicentral distances greater than 105 degrees [208], concluded that the wave pattern in the shadow zone depends on the shear modulus in the core.

Explosion Seismology

General Statement

The significance of explosion seismology in the Soviet Union is indicated by the rapid increase in the number of seismic crews, the versatility of field methods being developed, and also the number of Soviet books devoted exclusively to explosion seismology. Four significant books include:

1) N. N. Puzyrev [71], "Interpretation of Reflections Shooting Data, (1959), a detailed and up-to-date book on reflection shooting interpretation; 2) I. I. Gurvich [209], "Seismic Prospecting", (1954), an earlier, but detailed book on reflection and refraction exploration methods; 3) G. A. Gamburtsev, Yu. V. Riznichenko, I. S. Berzon, A. M. Yepinat'yeva, I. P. Pasechnik, I. P. Kosminskaya, and E. V. Karus [210], "Refraction-Correlation Method," (1952), describes in detail field procedures, interpretation, and instrumentation for refraction-correlation shooting as developed in the U. S. S. R., especially for studies of the earth's crust; and 4) I. S. Berzon [211], "High-Frequency Seismic Methods," (1957), which describes high-frequency methods used for investigations of relatively shallow structures as developed in the U. S. S. R.

The principal problems for the immediate future [56] in Soviet explosion seismology are to study propagation in various types of media; to develop methods for better interpretation of wave amplitudes and spectra; to determine coefficients of absorption, reflection, and refraction; to examine new interpretation parameters, particularly dispersion; and to develop automation and data-processing procedures. Since

945, G. A. Gamburtsev [56] has directed Soviet rograms toward:

1) extending the usable range of seismic vave frequencies to higher and lower frequenies; 2) studying the physical properties of vave propagation and developing methods utilizng amplitudes, frequency spectra, and other vave characteristics; and 3) investigating and tilizing non-longitudinal waves in addition to vorking with the conventional longitudinal waves.

Explosion seismology methods have been eveloped at the Institute of Earth Physics, J. S. S. R. Academy of Sciences; All-Union cientific Research Institute of Geophysical rospecting and other organizations under the Ainistry of Geology and Conservation of Natural Resources; Leningrad Division of the Mathenatical Institute, U. S. S. R. Academy of Sciences; and numerous Republic Academies of Sciences, articularly the Ukranian Institute of Geological ciences.

Most Soviet papers on seismic exploration ertain to particular problems in various areas f the U. S. S. R. and concern methods of investiation and solutions obtained. The investigations nclude nearly all areas in which seismic shootng can be carried out. The largest number of apers pertain to the Russian platform and the Volga-Ural regions.

eismic Exploration Expeditions: Besides conventional exploration, Soviet seismic expeditions have been placed in the field intermittently o make special investigations in selected areas. One of the earliest of these was the Korkino eismic Expedition, which recorded large explosions in Siberia in 1936. The Trans-Caucaian Seismic Expedition was sent into the field n 1946 by the Seismological Institute, U. S. S. R. Academy of Sciences. An expedition to make nderwater explosion studies and to determine eep crustal structures from explosions was ent in 1947-1949 by the Geophysical Institute, J. S. S. R. Academy of Sciences. The North Tien-Shan Expedition made deep crustal investiations from 1949-1951, recording large chemial explosions with the refraction-correlation nethod. The Tuimasa Expedition, under the irection of the All-Union Scientific Institute f Geophysical Methods of Prospecting, is one f the larger expeditions; it consisted of many ndividual crews and activities, employing bout 850 people.

Types of Seismic Investigation

Conventional seismic reflection and refraction methods have been highly developed. Soviet nvestigations have included studies of sedimentary sections, basement rocks, crustal and ubcrustal regions, shallow structures in gneous bodies, certain non-economic geologic eatures, and Arctic and Antarctic regions.

In basement, crustal, and subcrustal investigations, the Soviets have been more active than other countries. Low-frequency refraction techniques were developed by G. A. Gamburtsev and co-workers to provide a higher resolving power for investigations of the deeper regions. Since 1949, deep refraction investigations have been made in various parts of the U. S. S. R., and some were made at sea.

Two large underground chemical explosions were detonated relatively recently. Both were recorded with Soviet seismographs at great distances. In December 1957, 1,000 tons of high-energy explosive were detonated for scientific purposes in Tashkent in a mine shaft. In March 1958, 3,100 tons of similar explosive were detonated for making a canal in the Pokrovsk-Ural'skiy region [212].

Soviet investigations have also been made to detect faulting within sedimentary layers. Dyachkova and Sollogub were able to determine small fault offsets [213] by both reflection and refraction methods in the Carpathian area, largely evidenced by the existence of an anhydrite layer at depth. Raykher has also described fault displacements from seismograph data [214]. Starodubrovskaya has described attempts in 1951-1952 at the Geophysical Institute, U. S. S. R. Academy of Sciences, to locate and trace faults in areas of metamorphic rocks with high-frequency refraction-correlation methods [215].

Determinations of the shape of buried intrusive rocks have been made by Troyanskiy [216] with refraction techniques. Interpretation procedures followed the method developed by L.W. Gardner (United States) in 1949 for outlining the flanks of salt domes. It was concluded that seismic investigations of igneous structures were significant only for particular geologic features.

In engineering geology both reflection and refraction-correlation methods have been used. The refraction-correlation method is well suited for engineering hydrological exploration. Because of extensive background noise at engineering sites, low-frequency methods proved most satisfactory [217]. Seismic exploration has been done in coal mines and open-pit mines. Antsyferov and Kostantinova have recorded explosions in coal mines with seismographs [218]. Tarkhov has investigated wave propagation properties in open-pit mines [219].

Arctic and Antarctic seismic investigations were made as a part of the Soviet I. G. Y. program. No recent papers on this subject were located, however.

The effect of explosives in seismology have been described in several papers. A recent book includes photographs of explosions and

drilling in rock [220], demonstrating the efficiency of blasting and drilling mechanisms.

Methods of Seismic Exploration

Soviet methods of exploration have been summarized by Gamburtsev [221], with appendix by Riznichenko, and by Berzon [56]. Considerable Soviet activity is devoted to developing new exploration techniques, some of which have higher resolving powers and provide for greater resolution than methods used in the United States.

Soviet methods of seismic exploration include not only conventional reflection and refraction techniques, but since 1945, recording over a wide range of frequencies. Conventional reflection and refraction methods record waves in the range of 25-70 cps; low-frequency methods from 3 1/2 - 20 cps; and high-frequency methods from 70-500 cps. In all methods, reflection or refraction, high-, intermediate-, or low-frequency, emphasis is on correlating traces on seismograms. By 1949, refraction lines up to 400 km long were used. The instrumentation remained the same as in reflection shooting, except that amplifiers were made less noisy, amplification was increased, and seismometers were grouped in arrays. In some instances, large explosions for the longer profiles were detonated in lakes.

Some Soviet work has been done on utilizing transverse waves [222], although it has not been particularly successful. A method of refraction shooting in which the shot point is offset perpendicular to the line of seismometers, called a non-longitudinal profile or a transverse profile of refracted waves, is described by Gurvich [223]. Such refraction methods were found to be useful in areas of gentle dips (see in this review "Travel-time curves in explosion seismology", under "Interpretation Procedure for Explosion Seismology").

Refraction-Correlation Method: The refraction-correlation method is a basic Soviet technique in explosion seismology. It is used for low-frequency, intermediate-frequency and high-frequency refraction work. The book by Gamburtsev, et al [210], (1952), has described the basic physical principles, field techniques, data interpretation procedures, and instrumentation. The book includes a comparison of refraction-correlation with reflection shooting methods.

The refraction-correlation method differs from earlier refraction procedures by recording later refraction arrivals as well as the first refracted waves. The length of the refraction profile depends upon the desired depth of penetration. In refraction-correlation, the seismometer interval was made short enough for refracted energy to be correlated reliably from one trace to the next and seismometer arrays were used to increase recording sensitivity. Amplification was calibrated so that seismogram amplitudes were an accurate measure of ground motion. Widest application of the refraction-correlation technique has been in the investigations of basement and crustal features. The method can be applied effectively with medium-frequency recording for moderate depths and with high-frequency recording for shallow penetration.

Refraction methods, particularly the refraction-correlation methods, are effective in areas with layers exhibiting low velocity contrasts or areas with only velocity gradients. This has been indicated in two papers by Yepinat'yeva [224, 225]. The resolving power of the refraction method decreases rapidly when a relatively thick low-velocity layer is encountered at depth. The method can, however, be used in areas containing shallow high-velocity layers that are thin relative to wave length, where refractions can still be obtained from deeper layers [53].

Since 1949, deep refraction investigations have been made in the Balkash region, the Tran-Ili region, the Kirghiz Ridge region, southwest Turkmenia, the Caucasus, the Russian platform, northern Tien-Shan, the Pamir-Altay zone, the Trans-Caspian orogenic system, the Caspian Sea, and more recently, between the Asiatic continent and Pacific Ocean, particularly in the Okhotsk Sea.

The refraction-correlation method has also been applied to industrial problems, for differentiating sedimentary strata; in prospecting for oil structures, coal deposits [226], salt domes; for determining overburden depth to bedrock; and for differentiating surface clays, alluvial deposits, and near-surface conglomerates on the basis of velocities [227]. The method has also been used to trace a relatively shallow water-bearing sandstone and determine its characteristics [43].

It is only within the last few years that methods comparable to the Soviet refraction-correlation have been used in the United States and Canada. As Riznichenko [221] has stated, Soviet refraction-correlation methods are more effective for studying the earth's crust than methods developed in other countries, although marine seismic crustal investigations have been more widespread in the United States.

Low-frequency Refraction Method (3 1/2 - 20 cps): Low-frequency refraction methods are based on the refraction-correlation technique, but provide for deeper penetration and utilize low-frequency seismographs and amplifiers. A significant application of low-frequency refraction methods is to differentiate thick Paleozoic limestones [228] from the underlying basement, where a negligible velocity contrast exists between the two rock types.

A description of low-frequency refraction methods for deep crustal investigations appeared in a 1957 paper by Veytsman [229]. He used seismometers recording in the 6 to 14 cps range, although more recently 3 1/2 cps seismometers have been developed [230]. Amplifications of 300,000 to 400,000 were generally used, with maximum amplifications of 750,000, and microseismic background was reduced by using seismometer arrays. Intervals between the seismometer groups were less than 300 m and individual seismometer spreads ranged from 1 to 40 km in length. Intervals between spreads along the profile were 20 km or more. Thus, amplitude correlation was possible, velocities could be determined accurately, and seismometers were spaced closely over portions only of the refraction line. Veytsman described the main types of wave groups recorded, characteristics of these waves, and criteria for their identification. These criteria depend upon arrival time, apparent velocity, amplitude, and frequency. Studies were being extended to frequency spectrum, which may become a significant criterion.

Equipment used in low-frequency refraction shooting was described in a 1957 paper by Aksenovich, Gal'perin, and Zayonchkovskiy [231]. Profiles up to 400 km were recorded in the frequency range of 8 to 15 cps, using 4 mobile field units, each with 60 receiving channels. Four-stage amplifiers and low-frequency filters provided amplifications up to 750,000, which were used when recording with seismometer arrays.

Low-frequency refraction-correlation techniques have been applied in the Northern Tien-Shan region, southwest Turkmenia (1952), and the Pamir Mountains (1955).

High-frequency Methods (70 - 500 cps): High-frequency seismic reflection and refraction techniques in the recording range of 70 to 500 cps, were developed in the Soviet Union from 1946 to 1953. According to Gamburtsev and Berzon [233], the method has been applied successfully to strata as deep as 2 km.

Because high-frequency waves have a higher resolving power, they can be used to differentiate layered media with strata less than 50 m thick. The high-frequency methods can also be used for investigating characteristics of particular layers, e.g., water-bearing sands at relatively shallow depths, complex structures, and vertical layers. High-frequency methods find their main application in engineering problems and exploration for ore deposits.

High-frequency methods have obtained sufficient stature in the Soviet Union that Berzon has written a book [211] on them. This book provides a good summary of the development of high-frequency methods, shooting techniques used, application for investigating horizontal media at shallow and intermediate depths, and for investigations of vertically layered media. Results of investigations are described. Special high-frequency instrumentation has been described in a 1956 article by Berzon, Pariyskaya, and Starodubrovskaya [41]. High-frequency filters were used in conjuction with otherwise conventional recording apparatus.

Intermediate-frequency Methods (25 - 70 cps): The Soviets have made extensive field investigations with both refraction and reflection methods at conventional frequency recording, and often have recorded reflected and refracted waves on the same seismograms.

Refraction methods incorporate the refraction-correlation techniques described in this review under "Refraction-Correlation Method".

Reflection methods have been summarized in the book by N. N. Puzyrev, "Interpretation of Reflection Shooting Data" [71], (1959). This book indicates the wide variety of Soviet reflection-shooting techniques used and that Soviet field methods are as advanced as those elsewhere. Although the book is concerned with interpretation of reflection data, the shooting procedures used can be inferred.

Few papers have appeared in recent Soviet literature on methods of reflection shooting. This fact, combined with Soviet books, suggests that reflection methods have been well established in the U. S. S. R.

Pattern (multiple-hole) Shooting: Few Soviet papers referred to pattern shooting, a technique commonly used by U. S. seismic crews in areas where a high-velocity limestone layer is near the surface to increase the signal-to-noise ratio. Nikolayevskiy has pointed out, in an investigation of factors that control the character of waves [234] on seismograms, that character is determined primarily by the upper layers of the geologic section, and that character depends particularly on the elastic properties and thicknesses of these layers. Pattern shooting, Nikolayevskiy mentioned, is an effective procedure for increasing record quality when shooting in a high-speed layer, where recording frequencies are unusually high and the reflection quality low.

Weight-Dropping Source: No Soviet papers were noted on weight-dropping sources for deeper seismic exploration. This technique has been used successfully by some U. S. seismic crews since 1953. This method has the advantage of a low-frequency source without damage caused from dynamite. One Soviet application involves a procedure described by Khalevin, in which weights are dropped 2 meters for determining velocities of rocks along a surface outcrop [235]. Waves were recorded with piezoelectric

crystals.

Marine Shooting: As mentioned by Riznichenko [221], Soviet marine seismic investigations were less developed by 1958 than they were in the United States. In a 1958 paper, Koryakin described crustal structures in the Atlantic Ocean [236]. Several maps and numerous profiles were described, but much of the paper reviewed work in the Atlantic region reported by American and British investigators.

Gal'perin and Kosminskaya have described deep seismic profiling in the central Caspian Sea [237]. Nine different shooting procedures were tried, including fixed and movable shot points, continuous profiling, profiles with wide seismometer spacing, and single and multiple seismometer recording. It was recommended to use movable shots, individual seismometer recording, profiles in the Caspian area of 200-250 km length, and low-frequency recording equipment. The Soviets have also done other marine shooting.

Brekhovskikh published an article as early as 1949 on the distribution of sound in underwater sound channels [238]. Zverev has recently presented data on recording direct sound waves in water at distances up to 163 km and also presented analyses of ray paths in the ocean at these large shot-point offsets [239].

Air Shooting: Several Soviet papers on air shooting were published during the 1940's [240, 241], but none have been noted recently.

Other Methods: Vinogradov has attempted to correlate increases in rock pressures in coal mines, which lead to explosions and rock bursts, with amplitude, frequency, and periodicity of waves [242] from bursts in the mines. Magnetic tape recordings were used, but no general relationships were established. Some investigations have been made on soil creep with seismic methods, using spherical charges in homogeneous soils [243].

Seismometer Arrays and "Noise" Reduction

For many years Soviet seismologists have been active in array investigations, not only in exploration seismology, but also in recording large explosions. High amplifications required can be achieved by recording with seismometer arrays.

Reviews of array spacings used in explosion seismology appear in Chapter 8 of the book by Puzyrev [71]. Early papers on seismometer grouping are by Tsvetayev [244] and by Veytsman [245]. From 1944 to 1947, the All-Union Institute of Geophysical Methods of Prospecting undertook the problem of separating reflected waves from undesirable waves on seismograms. By 1949, according to Ryabinkin [246], a method had been developed which consisted of a group of nine seismometers recording per seismogram trace. Photoelectric summation of individual seismometer motions was used and additional frequency filtering was made. A separation of waves on the seismograms was obtained on the basis of the existence of common characteristics. Descriptions of conventional multiple seismometer spacings have been made by Voyutskiy [247], which included graphical analyses of numerous seismograms, showing the signal-to-noise ratio to increase with the number of seismometers per group and the orientations of the seismometers.

The optimum number of seismometers in an array has been investigated by Garasov [248], who presented graphs for the selection of optimum array parameters. The principal parameter was found to be the array diameter or length. A small number of seismometers per array was claimed to provide best results. Garasov has also investigated the effect of wave curvature [249] on seismometer grouping. Corrections were introduced to allow for sphericity of the wave-front by replacing a spherical wave with two-plane waves. Wave-front curvature was found to be insignificant, except for diffracted and scattered waves which have larger curvatures. Sphericity of the reflected wave front can be disregarded for small array spreads.

Voyutskiy and Slutskovskiy have investigated seismometer grouping to minimize undesirable waves, describing arrays as velocity filters [250]. First they analyzed such filtering with two seismometers and attempted to find optimum intervals for favorable noise cancellation. Later investigations included 10 seismometers per array [251] and it was concluded that the favorable array spread is equal to half the propagation velocity of the interfering wave times the apparent wave period.

Several Soviet papers have indicated using arrays also for ray directionality analyses. Napalkov has described seismometer group characteristics which affect the directional selectivity of an array [252]. Graphical and mathematical procedures were developed by which the directional sensitivity of seismic signals could be achieved by special orientation and seismometer placement within an array. Five examples of analyses of directional selectivities were given for arrays of varying complexities.

Two other papers by Isayev also concerned directionality from arrays in which the output from the seismometer group was determined as a function of emergence angle of the incoming wave [253]. Distortions of the dynamic properties of the group recording were investigated. Theoretical investigations of the directional effects of grouping and characteristics of the

directional group of certain incoming pulses were described for assumed source motions as a sinusoidal segment and as a quasi-sinusoidal pulse. It was concluded that arrays increased the signal-to-noise ratio in both reflection exploration shooting and in refraction-correlation shooting. It was also concluded that the signal-to-noise ratio improvement by an array is nearly the same for a pulse as it is for a segment of a sinusoidal wave.

Further studies on directionality of arrays were presented by Gal'perin [254], in which azimuthal grouping was investigated. A line of seismometers was oriented at various azimuths with respect to the profile. By changing the direction of the group line, the directional sensitivity of the group with respect to ground motion was altered. Equations for such groups were derived and methods discussed for obtaining multi-component azimuths on seismograms. The paper mentioned briefly the instrumentation used, including a polarizing seismic analyzer. Azimuthal grouping was shown to increase the sensitivity of an array. Signal-to-noise ratios of longitudinal waves were increased. Polarization studies of microseisms can be made in this way. Numerous illustrations of seismograms and figures were included in the paper.

Seismogram Noise Investigations: Most Soviet papers on reducing seismogram noise concern seismometer arrays, discussed in the previous section, and also electrical filters. A paper by Kosminskaya attempts to analyze interference phenomena of waves on seismograms, so as to separate compound harmonic vibrations into the component interfering seismic waves [255]. As interferences are a result of the superpositioning of several quasisinusoidal impulses, formulas were derived for two harmonic refracted waves with assumed apparent velocities and amplitude ratios entering over the length of the interfering zone. It was mentioned that compound waves on seismograms may appear as simple waves.

Interpretation Procedure for Explosion Seismology

Soviet interpretations of explosion data utilize not only travel-time curves and reflection cross sections, but also wave amplitude, absorption, diffraction, horizontal and vertical velocity gradients, and azimuthal direction of the incoming wave. Soviet interpretation of data from explosion seismology is described in several books. In addition to those mentioned previously [71, 209, 210, 211], there are:

1) L. V. Sorokin, V. O. Urison, L. A. Ryabinkin, and V. I. Kolitskiy [256], "Textbook on Geophysical Methods of Surveying Oil Deposits"; and 2) "Handbook of Seismic Prospecting" [257].

Time Corrections to Seismograms: Although no papers were observed to deal with time corrections to seismograms, a good summary of time corrections used in reflection shooting appears in Chapter 5 of the book by Puzyrev [71]. Correction procedures for surface heterogeneities are described and accuracies of time corrections are indicated.

Ray Path Interpretation: Numerous Soviet publications have concerned ray paths of body waves, i.e., those following Snell's Law. A summary of ray paths as used in reflection shooting appears in the book by Puzyrev [71], and paths of refracted waves appear in the books by Gamburtsev, et al.[210] and by Berzon [211].

Puzyrev [71] has treated ray paths for various seismological conditions, as the effect of geometric divergence of reflections from a thin layer, reflection from transitional layers, computations of amplitudes of reflected waves, the effects of horizontal and vertical velocity gradients on ray path, charts of ray paths and wave fronts for different velocity functions, reflection of compressional waves as shear waves, paths of reflected-refracted waves and refracted-reflected waves, determination of the vibration directions of incoming waves, and construction of cross sections of reflecting surfaces.

The effect of dipping layers on the azimuths of arriving waves has been investigated by F. S. Sultanov in connection with studies by the Shemakha Seismic Expedition [119] of 1953. Although the investigation pertained to earthquake waves, it was found that the azimuth of the arriving ray coincided with the source-to-receiver direction for horizontal strata, but that the azimuth was changed for dipping strata.

Oblogina has analyzed the effect of the interference between head waves and shear waves [258] in refraction shooting. Seismic exploration studies were made in 1954 by Vasil'yev to distinguish arrivals of various refracted waves which consist of longitudinal waves in certain media and shear waves in others [259]. For example, such waves might consist of P waves in the first three media and shear waves refracted back in the upper two. Similar conversions may exist in reflected waves. Numerous data were obtained, but no broad principles established.

Another study on transformed head waves (PSP) was described by Berzon [38]. Converted head waves on the Russian Platform were obtained only when the basement was granite. The PSP waves exhibited a wider variation of dynamic characteristics than the PPP; PSP waves usually contained lower predominant frequencies and exhibited larger damping.

Berzon and Ratnikova have shown that certain

types of interfering waves exist on seismic records from the Russian Platform [42]. These interferences were caused by alternating refracted waves, i. e., waves propagated as longitudinal waves in some layers and as transverse waves in others. In other papers Berzon has investigated the nature of seismic waves propagated through vertically stratified media which contain variable velocities. Amplitudes and velocities of head waves traveling along relatively thin layers with different velocities have been investigated by Davydova [19]. She made mathematical analyses of seismograms, relating vertical and horizontal wave displacements for different velocity differentiation in the media. Calculations were made for thin layers, using a Dirac pulse. Vertical components of amplitude at a receiving station were shown to change as a function of time both in magnitude and direction; the horizontal amplitude components changed only in magnitude. The relations between wave amplitude and velocity of propagation in the media were examined.

The accuracy of refracted wave data have been investigated by Khalevin [260]. The errors resulting in dip, depth, and velocity of the overlying media were analyzed. The dip error was found to become larger as the velocity contrast decreased.

Amplitudes of reflected and refracted waves for low angles of incidence [261] (less than critical angles) have been described by Filippov. Both plane and curved reflecting and refracting surfaces were considered. A proposed rule of thumb is that the amplitude of the reflected wave is approximately that of the incident wave times the reflection coefficient for a plane wave times the square root of the ratio of the radii of curvature of the reflected wave at the point of reflection to that at the point of recording. Refracted waves can be determined in a similar manner. In three-dimensional cases, the product of principal radii curvature of the wave front surface is used instead of the radii of curvature.

Travel-time Curves in Explosion Seismology: Travel-time curves play an important role in Soviet interpretation for both reflection and refraction shooting data. Analyses of travel-time curves for reflection shooting are discussed at length in the books by Puzyrev [71], Gurvich [209], and Kalenov [262]. Numerous technical articles on the interpretation of travel-time curves of both reflected and refracted waves have been published by Berzon and by Yepinat'yeva, and also others.

The necessity for making correct geologic assumptions, especially where low-velocity or thin high-velocity layers exist, was pointed out by Yepinat'yeva [263]. The need for combining reflection and refraction shooting was discussed and the best geologic assumption is that which most clearly duplicates the observed travel-time curve.

An analysis of travel-time curves by Kosminskaya showed that for amplitudes and phases of different components, an observed composite wave can be estimated by geophysical methods when the amplitudes and the phases of the components are substantially different [62].

The necessity for making corrections to reflection travel-time curves to allow for intermediate discontinuities has been discussed by Glotov [264]. He described simple graphical procedures for determining corrections. Priyma [265] has described methods for making corrections to travel-time curves for terrain and for weathered zones.

The effect of velocity variations on travel-time curves has been discussed in several papers. Yunusov [266] has investigated errors in the computations of reflections from travel-time curves on the Russian Platform when velocity in the upper zone is assumed constant. The need for using correct velocity variations in the upper zone was emphasized. Bogdanov [267] has discussed how to determine from travel-time curves the constants in velocity-depth equations which best apply to an area. Yepinat'yeva and Berzon wrote several papers during the 1940's on the effect of horizontal and vertical velocity gradients on travel-time curves of reflected waves. A paper by Zav'yalov and Timoshin [268] has stressed the need for refining reflected wave travel-time curves from the simple hyperbolic shape for reflections from curved surfaces.

Determinations of velocities and depth by reversed refraction profiling over curved surfaces was discussed by Timoshin and Zav'yalov [269]. Techniques of interpreting non-reversed refraction travel-time curves were discussed by Radzhabov [270], based on Gamburtsev's method, and were illustrated for a dipping refracting layer. The method has long been known in the United States. The use of longitudinal (PPP) and transformed (PSP) head waves as a means for determining seismic velocities and depths of layers more accurately has been discussed by Korovnichenko [271]. The method was illustrated with travel-time curves for both types of head waves for several different cases of dipping layers.

Transverse travel-time curves have been constructed for refraction and reflection shooting wherein the shot points are offset perpendicular to the line of profile. This method has been used since 1945 in the U. S. S. R. and is still being developed. In recent papers Radzhabov [272, 273] has described two techniques for determining velocities of refracting layers using transverse travel-time curves. One technique involves matching theoretical transverse

travel-time curves with observed travel-time curves. The other involves constructing travel-time curves for profiles along the same line shot from two adjacent shot points. From each shot the profiles overlap either entirely or partly. Where beds dip less than 15 percent, it was claimed, transverse travel-time curves can be used to determine dips and velocities of refracting layers. Equations were derived and graphical illustrations included in the paper.

Absorption in Explosion Seismology: Absorption of elastic waves in rocks is a property the Soviets have utilized effectively. Soviet investigations on absorption include seismic models, laboratory specimens of rocks, and field investigations. The most precise technique for determining absorption of rocks in situ has been with ultrasonic pulses in bore holes [274]. Such techniques have been developed at the Institute of Earth Physics.

In the late 1940's, Soviet investigations began to include measurements of amplitude in conjunction with seismic velocity and time. The amplitude variations were a measure of wave attenuation, which includes absorption. Such amplitude measurements, in conjunction with frequency analyses, resulted in the Soviet "dynamic" characteristics of seismic waves. These are in contrast to the Soviet kinematic measurements, which refer only to velocity and time. Since amplitude measurements are apparently obtained regularly in Soviet seismic work, absorption investigations are made routinely.

In the early 1950's several significant papers appeared on absorption from field studies. Ye. V. Karus wrote his Candidate's dissertation on absorbing properties of rocks in their natural occurrence by seismo-acoustic methods (Geophysical Institute, 1951). This work was continued by Karus and Pasechnik [275]. Yepinat'yeva [57] described methods for determining the difference in absorption coefficients from seismic waves. Riznichenko has also investigated the absorption of seismic waves, based on propagation through various media with different boundary conditions.

A significant Soviet investigation on absorption from field measurements concerns the incomplete masking of crystalline basement rocks by a thick section (several hundred feet) of limestone overlying basement rock of approximately the same velocity. Vasil'yev and co-workers [232] have shown that low-frequency refraction arrivals can be obtained from both the overlying limestone and the basement, but that absorption of the seismic waves is measurably higher in the limestone than the underlying basement.

Another paper concerns absorption coefficients in aquiferous sands as a criterion of water content. Berzon and co-workers [43] have used high-frequency refraction-correlation methods to differentiate a water-bearing sand from adjacent layers. It was found that the velocity of propagation in the sand was approximately constant throughout the area, but that its absorption coefficient varied over the area. These variations were found to be due to porosity and lithology variations.

Isochronal Methods of Interpretation: Isochronal methods concern plotting equal arrival-times of reflected and refracted waves as functions of horizontal distance from source. These techniques are of secondary importance, but have been described in several Soviet publications. A good review of isochronal techniques used in reflection shooting appears in Chapter 3 of the book by Puzyrev [71]. Somewhat earlier articles appear in the periodical literature. Timoshin [276] has described graphical methods of interpretation of isochronics. Berzon [277] has discussed isochronal methods of refracted waves, demonstrating that this method is applicable in areas of gentle dip with only plane interfaces.

Multiple Reflections: An early Soviet paper on multiple reflections was by G. A. Gamburtsev in 1945. During the early 1950's a number of papers have appeared by Yepinat'yeva and by Berzon. A summary of multiple reflections appears in Chapter 3 of the book by Puzyrev [71]. Analyses are given of simple and complex multiple reflections.

The difference in frequency content between multiple and simple reflections has been investigated by Yepinat'yeva and Mikhaylova [278]. Investigations in an area of good multiple reflections, where a layer at a 2, 400-foot depth with a reflection coefficient of 0. 3 provided many multiple reflections, demonstrated that single and multiple reflected waves were indistinguishable when recorded on conventional seismographs. With both high-frequency and low-frequency recording equipment, however, a larger number of single reflections were recorded by the high-frequency instruments. The effectiveness of high-frequency filtering for suppressing multiple reflected waves was also noted in another publication by Yepinat'yeva [279]. A mathematical investigation of multiple reflections of waves within a layer compared to single reflection from a greater depth has been made by Zvolinskiy [280]. Simplifying assumptions included reflection coefficients at the upper and lower boundaries of the layer.

Constructive interference of multiple reflections within a series of thin layers has been investigated by Yepinat'yeva [281]. Such constructive interference waves the author calls "summary" waves. For certain ratios of wave length, velocity, and thicknesses of the sequence of layers, constructive interference will produce reflected waves with larger amplitudes than a simple reflection from the top of the layer

sequence. In typical areas, where it can be assumed that the acoustic impedance increases with depth and the reflection coefficient is the same at each boundary, it was found that the number of reflecting strata required for the generation of summary waves increased as the reflection coefficient became smaller. For the previous assumption, it was calculated that amplitudes of summary waves are greater than those of simple reflected waves if the reflection coefficient is less than 0.02.

Velocity Determinations in Explosion Seismology

Soviet literature is extensive on velocity determinations from bore-hole shooting, borehole continuous logging, seismic reflection shooting, and seismic refraction shooting. The main Soviet contributors in this field are Yu. V. Riznichenko, I. S. Berzon, A. M. Yepinat'yeva, N. N. Puzyrev, and N. I. Khalevin. The more pertinent papers are mentioned here.

In 1948, Ye. F. Savarenskiy investigated the errors in functions which express velocity of longitudinal waves as a function of depth. In 1953, Riznichenko [282] published on seismic velocities in stratified media. Berzon [283] has determined refraction velocities in some metamorphic and some crystalline rocks and has obtained equations for effective velocities in areas where velocity changes with depth [284].

Borehole Velocity Determinations: Seismic velocities have been determined in the Soviet Union by conventional well shooting methods for many years. More recently velocity logging techniques have also been adopted.

A book on well shooting for petroleum geophysicists was written in 1957 by Puzyrev [285], "The Measurement of Seismic Velocity in Drill Holes". Petkevich [286] has described coordination of data from well shooting with surface reflection shooting so as to identify seismic reflecting layers. From corresponding amplitude measurements of waves recorded in the borehole and reflected at an interface, reflection coefficients were calculated. This technique was used in the pre-Carpathian depression.

An instrument for well-velocity shooting was described by Mozzhenko [287] in 1959 which consists of a new small-diameter seismometer with a 6 cps natural frequency. This instrument has been used in drill holes down to depths of 6,000 feet. A sketch of the instrument is included in the paper.

Continuous velocity logging with ultrasonic instruments has been developed in the Soviet Union by several different organizations since 1953. Soviet logging with ultrasonic methods thus lags by several years development in the United States. This is unexpected, for the Soviets have had considerable interest in differentiating rock properties and have had the capability in ultrasonics.

Riznichenko and co-workers [274] were investigating pulse-type ultrasonic seismic logging techniques before 1956. Karus and Tsukernik [288] have described an apparatus, including electronic circuits, developed at the Institute of Earth Physics, for ultrasonic logging in boreholes. This instrument can be used at temperatures not exceeding 40^{o}-50^{o}C, which means the instrument can be used down to depths of approximately 1 to 1.2 km. Two receivers were used. Interesting results with this apparatus were described in the paper, including identification of waves as PSP, PPP, and measurements of their amplitudes. From velocities of longitudinal and transverse waves, it was shown that Poisson's ratio could be determined within 5 percent. Other investigations from these data included frequency spectra analyses, wave-length determinations, and absorption in rocks from amplitude measurements.

Khalevin has described work on acoustic logging since 1953 at the Mining Geological Institute [289] of the Ural section of the U.S.S.R. Academy of Sciences. A pulsed source could be generated by magnetostrictive transducers, piezoelectric crystals, sparks, electromagnet hammers, or other emitters. The source used in cased boreholes was an electromagnet hammer, which provided a tapping on the casing wall. The receiving units were Rochelle salt crystals.

Velocity Determinations from Reflection Methods: The T^2-X^2 method, based on travel-time data, is commonly used. This method is described in Chapter 6 (70 pages are devoted to various aspects of velocity determinations) in the book by Puzyrev [71]. In a separate paper, Ryazanova [290] has described refinements of velocity determinations from reflection seismograms. Puzyrev [291] has investigated the effect of the curvature of the reflecting surface on the velocities calculated from travel-time curves and has also investigated [292] numerical methods for determining velocities from reflection data.

Murusidze [293, 294] has described a technique for obtaining average velocities by obtaining reflections from the same layer recorded along a common profile which was shot at both ends of the profile. The resultant travel-time curves he calls "overtaking travel-time curves". This method is applicable in areas where conventional reflection travel-time curves cannot be obtained over the required seismic spread length. It is claimed that this method has been used successfully since 1950 in several geophysical surveys in the Georgian S. S. R. Gurvich [295] has also published on a graphical-analytical method for determining effective ve-

locities of reflected waves using travel-time curves corresponding to a common profile with shots at either end of the line.

Velocity Determinations from Refraction Methods: Soviet methods for obtaining velocities from seismic refraction shooting are based on travel-time curves. These are standard techniques and have been described in the books by Gamburtsev, et al [210] and by Berzon [211].

Lyakhovitskiy [296] has investigated methods for determining geologic sections from refraction-correlation travel-time data. A method was proposed for determining the average velocity of an overburden section by refraction-correlation shooting, so that overburden thickness can be determined more accurately. The method is applicable in areas where the overburden medium contains one or more higher velocity layers. The method attempts to obtain a single layer equivalent for a multi-layered medium. The method provides a better approximation to actual conditions than the assumption of a homogeneous overburden with a velocity obtained from travel-time curves. This method was developed by Lyakhovitskiy in 1955 to interpret seismic data for a hydroelectric project along the Belaya River.

Matveyev and Martyanov [297] have investigated velocities in lignite, bituminous, and anthracite coals with ultrasonic refraction methods and found that the velocities were functions of the rank of coal. It was shown that anisotropy exists in coal seams; velocities were higher along the bedding than across it. Velocities of rocks along a surface outcrop were measured by Khalevin [235] with refraction methods. Elastic constants were also calculated from these velocities. A weight falling 2 meters was used as a source and piezoelectric crystals as receivers. Velocity measurements of longitudinal waves were reliable although Rayleigh waves were determined less accurately. The character of the surface waves was found to be affected by the condition of excitation. Results were in good agreement with laboratory data.

Seismoelectric Effect

The seismoelectric effect refers to the generation of electromotive forces by elastic waves in the ground. Since electromagnetic waves generated at an earthquake focus by the seismoelectric effect would travel many times faster than seismic waves, the existence of electric ground waves might be an indication of later seismic arrivals. Accordingly, the seismoelectric effect might have application in earthquake warnings, and it was because of this that the Soviets investigated the seismoelectric effect. Numerous field experiments have been made in the U. S. S. R. to determine the magnitude of this effect. Early Soviet workers in this field are A. G. Ivanov and Ye. I. Frenkel'. More recent work has been done by Ye. I. Parkhomenko and co-workers.

Volarovich and Parkhomenko [298-300] have investigated the piezoelectric effect in rocks between 1954 and 1957. It was found that this effect is significant in quartz-bearing rocks, such as granite, gneiss, quartzite, sandstone, and quartz. The piezoelectric effect was found to be a function of crystallographic orientation of the quartz grains. A measurable seismoelectric effect was observed in most rocks. More recently Volarovich and Parkhomenko [301] have shown that models provide significant means for studying the seismoelectric effect.

Although the primary purpose of the Soviet seismoelectric studies were to aid in the detection of earthquakes, it has been suggested by Parkhomenko that seismoelectric properties of rocks might be used to develop new methods of geophysical prospecting, directed toward identifying quartziferous rocks.

Instrumental Seismology

The broad aspects only of Soviet seismic instrumentation are mentioned, including instruments used in earthquake seismology, explosion seismology, and for miscellaneous recordings. Brief histories of the development of Soviet instrumental seismology were discussed in 1957 by Kirnos [302] and Savarenskiy [115]. Several other publications also include information on development of various instruments.

Earthquake Instruments

Descriptions of Soviet earthquake instrumentation as of 1955 have appeared in Part 2 of the book by Savarenskiy and Kirnos [116], "Elements of Seismology and Seismometry". In another 1955 book by Kirnos [303], "Some Problems of Instrumental Seismology", the design, operational characteristics, and construction of certain Soviet seismographs have been described in detail. Descriptions of more recent Soviet earthquake seismographs have appeared in the periodical literature.

The Soviets have developed three types of earthquake seismographs. One is for recording all types of waves from both distant and local shocks, the second is for recording only local shocks, and the third for recording strong earthquakes near their epicenters.

Soviet seismographs for recording distant and local shocks, which the Soviets refer to as seismographs of a general type, are electrodynamic (moving-coil) types of instruments. Instruments for recording local shocks, which the Soviets refer to as seismographs of the regional type, are short-period electrodynamic instruments with galvanometric recording having a high magnification over a narrow frequency range. Strong motion seismographs

for recording destructive earthquakes near epicenters consist of horizontal pendulums with mechanical recording.

Descriptions of Earthquake Seismographs: An outline of Soviet instruments for recording earthquakes includes:

1. Seismographs for recording distant and local shocks (seismographs of the general type).

   a. SVK and SGK vertical and horizontal component Kirnos types of seismographs. These are electrodynamic seismographs with galvanometric recording designed to provide a peak magnification of approximately 900 over a wide frequency range. Recording through a short-period galvanometer (GK-VI) provides a nearly uniform magnification for periods from 0.1 to 12 seconds. Longer periods (up to 30 seconds) can be obtained when recording through long-period (M-21) galvanometers. Magnification curves for these instruments have appeared in the literature [116, 304, 305]. The Kirnos instruments were first developed in the late 1940's and are now the standard recording instrument used at the principal Soviet earthquake recording stations.

   b. SVK-M and SGK-M vertical and horizontal component modernized SVK and SGK types of seismographs. These are 2.5 second-period instruments with high magnifications over a narrower frequency range. Peak magnifications of about 25,000 can be achieved at a period of 1 second when connected to a GK-VI type of galvanometer. Magnification curves are illustrated in an article by Pasechnik and Fedoseyenko [304, Figure 2], and were discussed by Pasechnik [117, Figure 4] at the 1959 Geneva Conference. These instruments were developed in 1951 and are now recording at several U. S. S. R. stations.

   c. VSG and GSG vertical and horizontal component Golitsyn types of seismographs. These are older electrodynamic seismographs with galvanometric recording. Descriptions of these seismographs are included in the book by Savarenskiy and Kirnos [116], "Elements of Seismology and Seismometry". They are no longer in common use.

   d. SN Nikiforov types of seismographs. These are older electrodynamic instruments with optical recording. These were once the common Soviet earthquake recording instruments, but since the late 1940's have been replaced with the Kirnos units. Only a few SN instruments remain in service. Descriptions of these instruments appear in the book by Savarenskiy and Kirnos [116].

   e. SI types of seismographs. These were designed by the Seismological Institute of the U. S. S. R. Academy of Sciences. These are older electrodynamic seismographs, apparently no longer in use.

2. Seismographs for recording local shocks (regional types of seismographs).

   a. VSKh and GSKh vertical and horizontal component Kharin types of seismographs. These are short-period electrodynamic instruments recording through galvanometers. They have high magnification over a narrow frequency range, with maximum peak magnifications ranging from 20,000 to 60,000 at a period of approximately 0.3 seconds. The recording range is for periods of 0.15 to 0.35 seconds. Magnification curves for these instruments are illustrated in Figure 97, Part 2, of the book by Savarenskiy and Kirnos [116], and also in Figure 2 in the article by Rustanovich [118]. The Kharin seismographs are widely used at Soviet earthquake stations which are located in areas of high seismicity.

   b. VEGIK electrodynamic seismographs and are used in a number of Soviet stations for recording local shocks. These seismographs have a somewhat broader magnification curve than the Kharin seismographs, although the peak magnification is less. Typical maximum magnifications are 7,000 over periods of 0.2 to 0.9 seconds. A typical magnification curve appears in Figure 1 of the article by Rustanovich [118].

3. Strong-motion seismographs for recording earthquakes near an epicenter.

   a. SMR-II strong-motion seismograph. This instrument consists of a horizontal pendulum with mechanical recording and electromagnetic damping. This seismograph re-

cords ground motion from 0. 2 to 9 seconds, has a static magnification of approximately 7. 2 and is designed for earthquakes of intensity less than 7 (weak to moderate earthquakes). This instrument has been described, with magnification curve included, in the book by Kirnos [303], "Some Problems of Instrumental Seismology".

b. SRZ-I strong-motion seismographs. These instruments consist of horizontal pendulums with mechanical recording, electromagnetic damping and auxiliary magnifying levers. Both long-period and short-period SRZ-I instruments have been designed. The long-period instrument records up to 3-second periods and the short-period instrument records about 0. 3-second periods. The static magnification of both instruments is approximately one. Descriptions of these instruments appear in the book by Kirnos [303].

The only Soviet long-period instruments currently in operation are the SVK and SGK Kirnos seismographs recording through long-period (M-21) galvanometers [305,155]. These permit recording of waves with periods of 30 seconds and more. Although the Soviets do not have an operative long-period seismograph to record waves with periods from 60 to 600 seconds or more, there was considerable discussion of current Soviet design and testing of long-period seismographs at both the 1st and 2nd Extended Seminar of the Institute of Earth Physics, U.S.S.R. Academy of Science, on the Study of Seismic Surface Waves [21] (December 1, 1957 and October, 1958). S. I. Nikonov there described a long-period instrument currently being designed and tested at the Simferopol' seismic station, which consists of a 70-second period seismometer recording through a 35-second period galvanometer. Its maximum magnification is 800 at 50-second periods, and has magnifications of 400 at 100 seconds, 100 at 200 seconds, and 36 at 300 seconds [21]. Kirnos discussed at the Seminar a long-period seismograph program that the Seismological Department of the Institute of Earth Physics has been developing since 1957. Experimental models of vertical seismographs have been recording waves with 100-200 second periods. The Seismological Department has also designed, but presumably not tested, a seismograph for recording waves with periods of 400-500 seconds.

The important SVK and SGK instruments were designed with broad amplitude characteristics in order to determine true periods and amplitudes of ground motion, which provide the data needed for interpretation of the dynamic characteristics of waves. Kirnos and Kondorskaya [306] have calculated the true values of first amplitudes of ground motion from recordings with these instruments. These seismographs have also been used to record waves with periods up to 30 seconds (recording through an M-21 type long-period galvanometer) in a significant study on surfact waves [305]. The peak magnifications of the SVK and SGK seismographs are, however, so small (900) that weak earthquakes and distant earthquakes are recorded only by a small number of stations, and sometimes only by the station nearest the epicenter. It was to obtain more widespread recording of earthquakes that the SVK-M and SGK-M seismographs were designed and constructed.

The operational characteristics of the short-period Kharin and VEGIK seismographs have been described by Rustanovich [118]. Short-period seismographs have been used successfully by Andreyev and Shebalin [307] in identifying and distinguishing such waves as the PS reflected from the deeper discontinuities in the crust. The conventional long-period seismographs would not be as suitable for detecting such waves, nor for determining depths to shallow discontinuities.

Kharin and Rulev [308] have described a strong-motion seismograph to be used near earthquake epicenters and near large explosions which can measure ground displacements up to 10 centimeters at frequencies from 1. 5 to 50 cps. The instrument consists of an inverted pendulum with electrical windings on its axis of rotation. Recordings of an oscillograph vary linearly with ground displacements. Another seismograph for recording strong motion, described by Medvedev [309], consists of a spherical pendulum suspended on a tripod which has a natural period of about 0. 25 seconds. Polar diagrams of deflections provide a measure of ground motion. Recordings of an 1, 800 ton explosion at a distance of 600 meters are included in the paper. A third type of strong-motion instrument, a short-period vertical seismograph with magnetic restoring force has been described by Popov [310]. The amount of damping and amplification of this seismograph can be varied widely, and the instrument is sturdy enough for use near destructive earthquakes.

Inclined seismometers, used for azimuthal recording at temporary stations, have been described in several papers. Gamburtsev and Gal'perin [311] have discussed these instruments in a 1954 paper, Pasechnik [312] in a 1956 article, and Savarenskiy and Kirnos [116] in their book, "Elements of Seismology and Seismometry". Inclined seismometers for azimuthal investigations do not appear to have as high a resolving power as properly spaced arrays.

Few Soviet papers pertained to strain seismographs, although during the 1940's several papers were noted. One was by Veshnyakov

[313], which described an instrument quite similar to the Benioff strain seismograph.

A seismic energy meter for measuring earthquake energy has recently been described by Belotelov, Veshnyakov, and Zhilyaev [314]. The instrument consists of three strongly damped mutually perpendicular seismographs which act as velocity meters, and includes functional converters and integrators. Significant measurements have been made in tests. Rykov [315] has recently described another energy-measuring device. This instrument automatically measures the square of the velocity of ground displacement, which it then integrates with respect to time. A light beam illuminates an area which is proportional to the square of the original deflection of the galvanometer, this is amplified with a photoelectric amplifier, and the amplified deflection is then integrated. Laboratory tests with this instrument have indicated significant measurements.

Instrumentation for Explosion Seismology

Seismic instrumentation used in Soviet explosion seismology as of 1954 has been summarized in the book by Gurvich [209]. Amplifiers, filtering circuits, automatic volume control units, galvanometers, oscillographs, and auxiliary instrumentation are included. Two types of seismometers are described, the SP-7 moving-coil type of seismometer and the SP-10 variable-reluctance type. Slutskovskiy [316] has described results of field and laboratory tests of several different Soviet seismographs in use by 1955. Numerous articles have concerned conventional seismometers and other instruments used in routine explosion seismology. These are not discussed here.

The NS-1, a 3.5 cps low-frequency exploration seismometer, including frequency characteristic curves and instrument design, has been described by Kovalev [230]. This instrument was developed in 1956 at the Institute of Earth Physics for low-frequency refraction-correlation investigations. It is more sensitive at low-frequencies than the Soviet seismometer model SEDS (natural frequency of 12 cps) or the more commonly used seismometer model SP-16 (natural frequency of 33 cps). By comparison, the VEGIK seismograph has a natural frequency of 1.5 cps. An earlier low-frequency electrodynamic seismometer is the SPSh, which is a broad-band instrument. Polshkov and Bereza [317] have reported that this seismometer, used with a broad-band filter, results in an output with better resolution and less frequency distortion than can be obtained with the conventional SS-24-48 or the high-frequency SS-26-51D apparatus.

Groshevoy and Pasechnik [318] have described a high magnification exploration seismometer in which high magnification is obtained by recording over a narrow frequency band near the seismometer resonant frequency. With sensitive galvanometers instrument magnifications as high as 1,000,000 can be achieved. Use of special amplifiers is not required and phase distortion is thus reduced.

Many papers pertain to optical systems for photographic recording, resonance phenomena of seismometers, various types of oscillographs, coupling factors between seismometers and galvanometers systems, phase and amplitude distortion in seismic apparatus, amplifiers, amplifier circuits, automatic gain control in seismic amplifiers, amplifiers designed for marine work, pressure pickups, piezoelectric instrumentation, ultrasonic instrumentation, and vibration platforms.

A comparison of the effects of transient pulses and steady-state sources upon seismic exploration equipment has been described by Melamud [319]. The investigation concerned the effects of different lengths of input signals upon the seismic apparatus. For a short input signal (less than "one period" in length), it was found that the apparatus was governed by its dynamic parameters. For an input of 3 periods or more, the apparatus was governed by its stationary characteristics.

A 52-channel seismic recording field unit has been described by Mozzhenko [320] in a 1955 paper. In a later paper, a 60-channel recording field unit, especially for refraction-correlation recordings, has been described by Aksenovich, Gal'perin, and Zayonchkovskiy [231]. Various types of seismometers and the amplifying circuits used in the 60-channel recording unit were described.

Soviet exploration equipment is apparently designed to provide for a mixing of channels. Priyma [321] has proposed improvements in the performance of the 60-channel seismic recorder model PPS-60M by expanding its mixing scheme. Methods were described and circuit diagrams included to permit one channel to record energy from the adjacent 3 or 4 channels.

Magnetic Tape Recording: The earliest Soviet publication noted on magnetic tape recording is that by Groshevoy [322], pertaining to the design and calculation of magnetic systems for geophysical instruments. A recent paper on recording with magnetic tape is that by Melamud, Khudzinskiy and Deinega [323]. Frequency-modulated magnetic-recording units have been constructed which consist of a 9-channel magnetic recording and reproducing unit, with corresponding amplifiers, and a 9-channel conventional recording unit, with a separate set of amplifiers. A wide range of filters can be used in conjunction with the tape recording so that records can be obtained anywhere within

the frequency range of 20 to 500 cps. The circuits can also be modified to permit recording at frequencies below 20 cps for low-frequency refraction shooting. The magnetic tape unit is claimed to be distortion-free and is therefore well suited for studying the dynamic characteristics of seismic waves. These units have been mounted on field trucks and other portable units can also be developed.

Other Instruments

Several Soviet stations have installed the Bonchkovskiy type tiltmeters. These are horizontal pendulum instruments in which the pendulum is maintained in an almost horizontal position by thin torsion wires that permit some rotation. These tiltmeters are illustrated in Part II, Figure 42, of the book by Savarenskiy and Kirnos [116], "Elements of Seismology and Seismometry". The Gamburtsev tiltmeter is another type which consists of a combination of vertical and horizontal pendulums. It is also illustrated in the book by Savarenskiy and Kirnos [116], Figure 43a, and has been described by Gamburtsev [324] in the periodical literature. In 1954, Bonchkovskiy and Namsara [325] made an analysis of the precision of tiltmeters.

Bonchkovskiy [326] described instruments in 1955 that can measure slow movements of the earth's surface. Also in 1955, Bonchkovskiy and Latynina [327] described an instrument for measuring angular displacement between two rigid bodies. This apparatus consisted of two piers with in-line bars connected to each pier. A thin cylindrical rod was placed between the ends of the bars and slightly squeezed. It was possible to measure small angular displacements in this cylinder. In 1957, Bonchkovskiy and Karmaleyeva [328] analyzed the effect of fiber torsion on the readings of pendulum clinometers. It was concluded that there was a reading range over which distortion due to fiber torsion was negligible.

Shakurov [329] has described a recent apparatus, which is still in an experimental stage, for determining small tilts of the earth's surface. It utilized two discs of identical large curvature, held apart at a distance of approximately 0. 1 micron by injected gas streams. The lower disc is attached to the housing and moves with a small tilt of the ground. The upper disc will "swim" on the surface of the lower disc. Thus, a tilt produces a change in relative positions of the discs. Angles as small as 0. 02 seconds of arc have been measured in models of this instrument.

Electrodynamic microbarographs have been described in a paper by Pasechnik and Fedoseyenko [330], which measure atmospheric fluctuations and relate them to microseismic background. The construction and operation of two different microbarograph models were described. In one model, a displacement of a bronze membrane on one side of a hermetically sealed chamber is measured by an electrodynamic transducer and recorded through galvanometers. The second model is similar to that which has been used by Gutenberg and Benioff in the United States for a number of years.

REFERENCES

References to Soviet journals which have been translated into English are here listed by the translated journal name, and pages refer to the translated issues. References to journals which have not been translated at the time of this writing are referred to by the transliterated journal name and pages refer to the Soviet issues. The entries are listed in the order of citation in the review; an alphabetical key to senior authors follows the list.

1. Skuridin, G. A. , The Jumps in the Discontinuous Solutions of the Dynamic Equations of the Theory of Elasticity: Izvestiya AN, SSSR*, Seriya Geofizicheskaya, no. 6, p. 625-633, 1956 (Geophysical Abstracts 166-109).

2. Skuridin, G. A. , Principle of Double and Asymptotic Solutions of the Dynamic Equations in the Theory of Elasticity, Part I and Part II: Bull. , Acad. Sci. U. S. S. R. , Geophysics Series, no. 1, p. 3-10 and no. 3, p. 337-343, 1959.

3. Skuridin, G. A. , and Gvozdev, A. A. , Boundary Conditions for the Jumps of Discontinuous Solutions of Dynamic Equations of the Theory of Elasticity: Bull. , Acad. Sci. U. S. S. R. , Geophysics Series, no. 2, p. 145-156, 1958 (Geophysical Abstracts 173-121).

4. Zvolinskiy, N. V. , and Skuridin, G. A. , Asymptotic Methods of Solutions of Dynamic Problems of Elasticity Theory: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 2, p. 134-143, 1956 (Geophysical Abstracts 165-75).

5. Petrashen', G. I. , Smirnova, N. S. , Gel'chinskiy, B. Ya. , Some Problems in the Dynamic Theory of Elasticity for Media Containing Cylindrical or Spherical Boundaries: Uchenyye Zapiski, Leningrad State University, no. 170, 1953.

6. Petrashen', G. I. , Smirnova, N. S. , and Makarov, G. I. , Asymptotic Representations of Cylindrical Functions: Uchenyye

*AN, SSSR is Akademiya Nauk, S.S.S.R.

Zapiski, Leningrad State University, vol. 27, no. 170, 1953.

7. Shemiakin, Ye. I., A Method of Integration of Non-Stationary Linear Boundary Value Problems on the Propagation of Disturbances in Non-Ideally Elastic Media: Prikladnaya Matematika i Mekhanika, vol. 22, no. 3, p. 289-300, 1958.

8. Mikhlin, S. G., Fundamental Solutions of Dynamic Elasticity Equations in a Non-Homogeneous Media: Prikladnaya Matematika i Mekhanika, no. 4, 1957.

9. Brekhovskikh, L. M., Waves in Layered Media: Moscow, 1957.

10. Petrashen', G. I., Data on Quantitative Studies of the Dynamics of Seismic Waves: 3-volume monograph, Vsesoyuznyy Naucho-Issledovatelskiy Instituta Razvedochnoy Geofiziki, vol. 2, 153 p., 1957 (Geophysical Abstracts 179-357).

11. Petrashen', G. I., Lamb-Problem for the Case of the Elastic Semi-Space: Doklady AN, SSSR, vol. 64, no. 5, p. 649-652, 1949.

12. Petrashen', G. I., Wave Propagation in Laminated Isotropic Media Containing Inclined Layers: Uchenyye Zapiski, Leningrad State University, no. 117, p. 105-147, 1954.

13. Ivakin, B. N., Similarity of Elastic Wave Phenomena, Part I and Part II: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 11, p. 1269-1281 and no. 12, p. 1348-1388, 1956 (Geophysical Abstracts 168-63).

14. Ivakin, B. N., Head Waves, Normal Waves, and Other Waves in a Thin Rigid Layer in a Fluid: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 35 (162), p. 88-115, 1956 (Geophysical Abstracts 171-103).

15. Ivakin, B. N., Micro- and Macro-Structure of Elastic Waves in Heterogeneous Media: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 39 (166), p. 1-92, 1958.

16. Ogurtsov, K. I., and Burova, A. V., Intensities of Longitudinal and Transverse Waves Propagating at the Boundary of a Half-Space: Bull. Acad. Sci. U. S. S. R., Geophysics Series, no. 2, p. 93-96, 1958 (Geophysical Abstracts 173-127).

17. Zvolinskiy, N. V., Reflected and Head Waves Originating on a Plane Boundary Between Two Elastic Media, Parts I, II, and III: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 10, p. 1-21, 1957, no. 1, p. 1-8, and no. 2, p. 97-101, 1958 (Geophysical Abstracts 172-57, 173-131).

18. Zaytsev, L. P., and Zvolinskiy, N. V., A Study of Axi-Symmetrical Head Waves Originating at a Plane Boundary Separating Two Media: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 5, p. 40-50, 1951 (Geophysical Abstracts 147-13144).

19. Davydova, N. I., Dependence of the Dynamic Characteristics of Longitudinal Head Waves Produced in Thin Layers on the Velocity Contrast Between the Layers: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 10, p. 684-688, 1958 (Geophysical Abstracts 176-76).

20. Davydova, N. I., Dependence of Amplitude on Continuous Head Waves, Coupled to Thin Layers, for Velocities of Differentiated Media: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 5, 1959.

21. Arkhangel'skaya, V. M., Extended Seminar of the Department of Seismology and Seismic Service, Institute of Earth Physics, for the Study of Surface Waves and Second Extended Seminar of the Department of Seismology and Seismic Service of the Institute of Earth Physics for the Study of Surface Waves: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 12, p. 890-894, 1958, and no. 4, p. 449-451, 1959.

22. Gogoladze, V. G., Reflection and Refraction of Elastic Waves, General Theory of Boundary Rayleigh Waves: AN, SSSR, Trudy Seysmologicheskiy Instituta, no. 125, p. 1-42, 1947 [Translation, Int. Geol. Rev., v. 2, no. 5, 1960, p. 418-452].

23. Naymark, M. A., Vibrations of a Thin Layer Overlying an Elastic Half-Space Under the Effect of a Vertical Harmonic Force Applied to the Free Surface of a Layer, Parts I and II: AN, SSSR, Trudy Seysmologicheskiy Instituta, no. 119, p. 46-62, 1947 and no. 127, p. 1-15, 1948.

24. Naymark, M. A., Evaluation for Depth of the Absolute Value of the Real Roots of the Equation of Frequencies of an Elastic Layer Lying on an Elastic Half-Space: AN, SSSR, Trudy Seysmologicheskiy Instituta, no. 127, p. 16-25, 1948.

25. Naymark, M. A., Vibrations of a Thin

Elastic Layer Placed on an Elastic Hemisphere: AN, SSSR, Trudy Seysmologicheskiy Instituta, no. 127, p. 26, 1948.

26. Naymark, M. A., Roots of the Frequency Equation of an Elastic Layer Overlying an Elastic Half-Space: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 1 (128), p. 3-10, 1948.

27. Keylis-Borok, V. I., Surface Waves in a Layer Overlying an Elastic Half-Space: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 2, p. 17-39, 1951.

28. Keylis-Borok, V. I., Frequency Equation for a Multi-Layered Elastic Medium: Doklady AN, SSSR, vol. 87, no. 1, p. 25-28, 1952 (Geophysical Abstracts 151-14032).

29. Keylis-Borok, V. I., Problem of the Propagation of Stationary Vibrations in a Layer Lying Between Two Semi-Spaces: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 20 (147), p. 20-36, 1953 (Geophysical Abstracts 160-71).

30. Keylis-Bork, V. I., Asymmetrical Interference Waves in a Layered Medium: Doklady AN, SSSR, vol. 107, no. 4, p. 533-536, 1956 (Geophysical Abstracts 165-84, Translation, Int. Geol. Rev., v. 2, no. 7, 1960, p. 577-581).

31. Keylis-Borok, V. I., Problem of the Resonance Property of the Interference Waves in a Layer: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 22 (149), p. 50-58, 1956 (Geophysical Abstracts 164-89).

32. Keylis-Borok, V. I., and Stesin, I. M., Dispersion of Rayleigh Waves in a Two-Layer Model of the Earth's Crust: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 1, p. 14-16, 1959 (Geophysical Abstracts 177-90).

33. Yanovskaya, T. B., Determination of the Dynamic Parameters of the Focus from Surface Waves: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 3, p. 161-167, 1958.

34. Petrashen', G. I., Certain Interference Phenomena in a Two-Layered Medium: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 10, p. 22-36, 1957 (Geophysical Abstracts 172-60).

35. Petrashen', G. I., and Yenal'skiy, V. A., Some Phenomena of Interference in a Medium Containing Thin Parallel Planes, Parts I, II, and III: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 9, p. 1009-1020, no. 10, p. 1129-1144, no. 11, p. 1241-1257, 1956 (Geophysical Abstracts 168-66).

36. Brekhovskikh, L. M., Reflection of Spherical Waves from Plane Boundaries Separating Two Media: Zhurnal Tekhnicheskoy Fiziki, vol. 18, no. 4, p. 455-472, 1948 (Geophysical Abstracts 134-10282).

37. Brekhovskikh, L. M., Reflection of Spherical Waves from Interfaces of Low Velocity Contrast: Zhurnal Tekhnicheskoy Fiziki, vol. 18, no. 4, p. 473-482, 1948 (Geophysical Abstracts 135-10550).

38. Berzon, I. S., Experimental Data on Converted Refracted PSP Waves: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 6, p. 397-407, 1958 (Geophysical Abstracts 175-368).

39. Berzon, I. S., Certain Spectral Features of Waves Reflected from Thin Layers: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 5, 1959.

40. Berzon, I. S. and Yepinat'yeva, A. M., Multiple Refracted Waves: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 4, p. 9-32, 1952.

41. Berzon, I. S., Pariyskaya, G. N., and Starodubrovskaya, S. P., Recording High-Frequency Reflected Waves on the Russian Platform: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 6, p. 644-656, 1956.

42. Berzon, I. S., and Ratnikova, L. I., Nature of Certain Waves Obscuring Detection of Reflected Waves on the Russian Platform: Bull., Acad. Sci. U.S.S.R., Geophysics Series, no. 6, p. 1-15, 1957 (Geophysical Abstracts 171-337).

43. Berzon, I. S., Vasil'yev, Yu. I., and Starodubrovskaya, S. P., Wave Refraction by Aquiferous Sands, Parts I and II: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 1, p. 17-29, no. 2, p. 115-118, 1959 (Geophysical Abstracts 177-349).

44. Fedotov, S. A., Approximate Determination of Dynamic Travel-time Curves of Waves Refracted at Curved Interfaces: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 35 (162), p. 42-50, 1956 (Geophysical Abstracts 171-106).

45. Fedotov, S. A., in Chronicle: Bull., Acad., Sci. U. S. S. R., Geophysics Series, no. 1, p. 114, 1959.

46. Alekseyev, A. S., and Tsepelev, N. V., Amplitudes of Reflected Waves in Laminated Non-Homogeneous Elastic Media: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 9, p. 1021-1035, 1956 (Geophysical Abstracts 168-61).

47. Tsepelev, N. V., Reflection of Elastic Waves in a Non-Homogeneous Medium: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 1, p. 5-8, 1959 (Geophysical Abstracts 177-81).

48. Malinovskaya, L. N., Dynamic Characteristics of Longitudinal Waves Reflected Beyond the Critical Angle: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 5, p. 22-29, 1957 (Geophysical Abstracts 170-280).

49. Malinovskaya, L. N., Dynamic Characteristics of Totally Reflected Transverse Waves: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 2, p. 106-113, 1958 (Geophysical Abstracts 173-128).

50. Chekin, B. S., Wave Form Changes on Reflection and Refraction: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 4, p. 36-46, 1957 (Geophysical Abstracts 170-81).

51. Chekin, B. S., Spectra of Waves Reflected and Refracted by a Plate: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 11, p. 738-742, 1958.

52. Chekin, B. S., Reflection and Refraction of Seismic Waves at a Weak Interface: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 1, p. 9-13, 1959 (Geophysical Abstracts 177-83).

53. Berzon, I. S., and Yepinat'yeva, A. M., On Seismic Masking: Izvestiya AN, SSSR, Seriya Geograficheskaya i Geofizicheskaya, vol. 14, no. 6, p. 473-500, 1950 (Geophysical Abstracts 144-12636).

54. Petrashen', G. I., Statement on a Problem and Method for the Solution Concerning Seismic Screening of Waves by Thin Layers: Uchenyye Zapiski, Leningrad State University, no. 177, 1954.

55. Babich, V. M., and Alekseyev, A. S., Screening Effect Produced by a Thin Elastic Layer: Doklady AN, SSSR, vol. 91, no. 4, 1953 (Geophysical Abstracts 159-87, Translation, Int. Geol. Rev., v. 2, no. 6, 1960, p. 527-529).

56. Berzon, I. S., Developments of Seismic Prospecting in the Soviet Union: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 11, p. 38-50, 1957 (Geophysical Abstracts 172-219).

57. Yepinat'yeva, A. M., Method of Determining the Difference of the Absorption Coefficients of Seismic Waves: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 3, p. 70-77, 1952.

58. Riznichenko, Yu. V., Propagation and Absorption of Seismic Waves: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 35 (162), 1956.

59. Ivakin, B. N., On Modeling of Absorption of Seismic Waves: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 7, p. 468-474, 1958 (Geophysical Abstracts 176-82).

60. Ivakin, B. N., Calculation and Modeling of the Absorption of Seismic Waves: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 11, p. 743-754, 1958.

61. Karus, Ye. V., Absorption of Elastic Vibrations in Rocks During Stationary Excitation: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 4, p. 249-254, 1958 (Geophysical Abstracts 174-77).

62. Kosminskaya, I. P., Methods for the Analysis of Amplitude and Travel-time Curves of Phases of Complex Harmonic Waves: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 30 (157), p. 302-313, 1956 (Geophysical Abstracts 165-85).

63. Kosminskaya, I. P., Amplitude and Travel-time Curves of Phases of Seismic Waves on the Free Boundary of a Half-Space: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 1, p. 37-47, 1956 (Geophysical Abstracts 165-332).

64. Brekhovskikh, L. M., Diffraction of Waves from an Irregular Surface: Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, vol. 3, no. 9, 1954.

65. Makarov, G. I., and Petrashen', G. I., Non-Stationary Diffraction of Acoustic and Electromagnetic Waves by a Sphere: Uchenyye Zapiski, Leningrad State University, no. 170, 1953.

66. Oblogina, T. I., Dynamic Characteristics of Diffracted Elastic Waves: Izvestiya AN, SSSR, Seriya Geofizicheskiya, no. 4, p. 377-390, 1956 (Geophysical Abstracts 166-120).

67. Oblogina. T. I., Diffracted Seismic Waves: Prikladnaya Geofizika, no. 20, p. 25-45, 1956 (Geophysical Abstracts 179-369).

68. Skuridin, G. A., Some Problems of Approximate Theory of Elastic Wave Diffraction: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 2, 1954.

69. Skuridin, G. A., Approximate Solution of the Problem of Diffraction of a Plane Elastic Longitudinal Wave at a Horizontal Fault: AN Gruzinskoy SSR, Trudy Instituta Geofiziki, vol. 14, p. 79-90, 1955 (Geophysical Abstracts 176-75).

70. Petrashen', G. I., Nikolaev, B. G., and Kouzov, D. P., Series Method in the Theory of Wave Diffraction About Plane Angular Regions: in Symposium on Dynamic Problems in Elasticity Theory: Uchenyye Zapiski, Leningrad State University, 1957.

71. Puzyrev, N. N., Interpretation of Reflection Shooting Data, Moscow, 1959, 451 p.

72. Alekseyev, A. S., Lamb-Type Problems for Wave Equations for a Linearly Non-Homogeneous Medium: Uchenyye Zapiski, Leningrad State University, no. 246, 1957.

73. Babich, V. M., Hadamard's Method in the Dynamics of a Non-Homogeneous Elastic Medium: Bull., Leningrad State University, Seriya Matematikaya, no. 1, 1956.

74. Ivakin, B. N., Micro- and Macro-Structures of Elastic Waves in Unidimensional Infinite Heterogeneous Media: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 39 (166), p. 1-92, 1958 (Geophysical Abstracts 175-77).

75. Berzon, I. S., Certain Dynamic Peculiarities of Waves Propagating in a Vertically Stratified Medium: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 35 (162), p. 51-87, 1956 (Geophysical Abstracts 171-107).

76. Brekhovskikh, L. M., Theory of the Displacement of Waves in Internal Total Reflection of a Spherical Wave: Zhurnal Tekhnicheskoy Fiziki, vol. 21, no. 8, 1951.

77. Babich, V. M., Ray Method Calculation of Intensive Frontal Distrubances: Doklady AN, SSSR, vol. 110, no. 3, 1956.

78. Babich, V. M., and Alekseyev, A. S., Ray Method of Calculating the Intensity of Wave Fronts: Bull., Acad. Sci. U.S.S.R., Geophysics Series, no. 1, p. 9-16, 1958, (Geophysical Abstracts 175-81).

79. Monakhov, F. I., Determination of the Displacement Direction in a Transverse Wave: AN, SSSR, Trudy Geofizicheskogo Instituta, vol. 9, (136), 1950 (Geophysical Abstracts 146-12934).

80. Parkhomenko, I. S., The Intensity of a Wave that Traverses a Series of Layers with High Velocity, Parts I and II: Bull., Acad. Sci. U. S. S. R., Geophysics Series, no. 5 and no. 6, 1959 (Geophysical Abstracts 179-119).

81. Kogan, S. Ya., Determination of Energy of Body Seismic Waves: Bull., Acad. Sci., U. S. S. R., Geophysical Series, no. 9, 1959.

82. Keylis-Borok, V. I., The Relation Between Point Sources and Three-Dimensional Sources: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 4, 1956, (Geophysical Abstracts 166-81).

83. Karus, Ye. V., and Pasechnik, I. P., The Nature of Elastic Waves Produced in Real Media by a Harmonic Source: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 2, p. 89-100, 1955 (Geophysical Abstracts 161-64).

84. Ogurtsov, K. I., Quantitative Investigations of the Wave Processes of Elastic Half-Spaces in Response to Different Types of Exciting Forces: Uchenyye Zapiski, Leningrad State University, no. 208, 1956 (Geophysical Abstracts 168-60).

85. Konstantinova, A. G., The Dynamics of Sudden Bursts of Coal and Gas in Mines, According to Results of Seismo-Acoustic Observations: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 2, p. 150-158, 1959 (Geophysical Abstracts 177-348).

86. Konstantinova, A. G., Form of the Elastic Impulse Produced by Disruption of Mining Rocks: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 4, p. 421-426, 1959.

87. Riznichenko, Yu. V., Development of Ultrasonic Methods in Seismology: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 11, p. 31-37, 1957 (Geophysical Abstracts 172-242).

88. Riznichenko, Yu. V., Ivakin, B. N., Bugvov, V. R., Model Experiments with Seismic Waves: Izvestiya AN, SSSR,

Seriya Geofizicheskaya, no. 5, 1951.

89. Riznichenko, Yu. V., Ivakin, B. N., Bugvov, V. R., The Pulse Ultrasonic Seismoscope: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 1, 1953.

90. Riznichenko, Yu. V., and Shamina, O. G., Elastic Waves in Solid Stratified Medium Using Two-Dimensional Models: Bull., Acad. Sci., U.S.S.R., Geophysics Series, no. 7, p. 17-37, 1957 (Geophysical Abstracts 172-59).

91. Riznichenko, Yu. V., and Shamina, O. G., Elastic Waves in Layers of Certain Thicknesses Investigated with Two-Dimensional Models: Bull. Acad. Sci. U. S. S. R., Geophysics Series, no. 3, p. 231-243, 1959.

92. Ivakin, B. N., Elastic Media with Imperfect Elasticity and Their Models: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 2, p. 138-144, 1959.

93. Parkhomenko, I. S., Model Study of the Propagation of a Head Wave Passing Through a High Velocity Layer: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 2, p. 114-117, and no. 4, p. 255-259, 1958 (Geophysical Abstracts 174-83, and 174-84).

94. Gzovskiy, M. V., The Modeling Method in Tectonophysics: Sovetskaya Geologiya, no. 4, p. 53-72, 1958, (Translation, Int. Geol. Rev., v. 1, no. 4, 1959, p. 31-47).

95. Schreiner, L. A., Physical Principles of the Mechanics of Rocks: Moscow, Leningrad, 1950.

96. Volarovich, M. P., and Balashov, D. B., Study of the Effect of Hydrostatic Pressure up to 1,000 kg/cm^2 on the Velocity of Propagation of Elastic Waves in Specimens of Coal: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 34 (161), p. 164-174, 1956 (Geophysical Abstracts 169-93).

97. Volarovich, M. P., and Balashov, D. B., Study of Elastic Wave Velocity in Specimens of Rock Pressures of 5,000 kg/cm^2: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 3, p. 56-69, 1957 (Geophysical Abstracts 170-186).

98. Silayeva, O. I., Methods of Studying the Elastic Properties of Specimens of Rocks under Pressure: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 2, p. 145-149, 1959 (Geophysical Abstracts 177-97).

99. Riznichenko, Yu. V., Seismo-Acoustics for Study of Rock Tension: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 6, p. 538-540, 1955 (Geophysical Abstracts 164-301).

100. Riznichenko, Yu. V., and Silayeva, O. I., Determination of Relationship Between Velocities of Propagation of Elastic Waves in Specimens of Rock and Uniaxial Pressure: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 3, p. 193-197, 1955 (Geophysical Abstracts 162-112).

101. Riznichenko, Yu. V., Silayeva, O. I., Shamina, O. G., Myachkin, V. I., Glukhov, V. A., Vinogradov, S. D., Seismo-Acoustic Method of Studying Stress Conditions in Rocks, Models, and in Solid Masses: AN, SSSR, Trudy Geofizicheskaya Instituta, no. 34 (161), p. 74-163, 1956 (Geophysical Abstracts 169-315).

102. Shamina, O. G., Frequency Analysis of Seismic Vibrations: AN, SSSR, Trudy Geofizicheskogo Instituta, 1954.

103. Slutskovskiy, A. I., Frequency Analyses of Seismic Vibrations: Naucho-issledovatel'skogo Geofizirazvedochnogo Instituta, Moscow, 1956.

104. Voyutskiy, V. S., and Slutskovskiy, A. I., Frequency Analyses of Station of Seismic Waves: Prikladnaya Geofizika, no. 8, 1952.

105. Bereza, G. V., Slutskovskiy, A. I., and Polshkov, M. K., Frequency Analyses of Seismic Vibrations: Prikladnaya Geofizika, no. 11, p. 92-123, 1954 (Geophysical Abstracts 165-351).

106. Bereza, G. V., Instrumental Equipment for Frequency Analysis of Seismic Oscillations in the Laboratory: Prikladnaya Geofizika, no. 16, p. 37-49, 1957 (Geophysical Abstracts 172-238).

107. Khudzinskiy, L. L., and Melamud, A. Ya., Frequency Analyzer for Seismic Waves: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 9, p. 24-45, 1957 (Geophysical Abstracts 173-350).

108. Obukhov, V. A., Improvement of the UZS-2 (31) Seismoscope: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 10, 1959.

109. Gol'tsman, F. M., The Question of Frequency Analysis of Seismic Waves: Vestnik, Leningrad State University, no. 2, 1952.

110. Gol'tsman, F. M., Graphical Analytical Method of Analysis of Seismic Waves: Vestnik, Leningrad State University, Seriya Fiziki i Khimy, vol. 16, no. 3, p. 45-56, 1956.

111. Gol'tsman, F. M., Use of Linear Systems for Filtering Composite Oscillations: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 5, p. 42-52, 1957 (Geophysical Abstracts 170-286).

112. Gol'tsman, F. M., Inverse Frequency Characteristics of Filtered Seismic Signals: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 4, p. 378-384, 1959.

113. Gryn, M. Ye., Spect_a of One Type of Impulse: Dopovide Academiyi Nauk Ukrayins'kogi SSR, no. 9, p. 967-970, 1959.

114. Solov'yev, S. L., Development of the Seismic Service of the U. S. S. R.: Vestnik AN, SSSR, no. 6, 1959.

115. Savarenskiy, Ye. F., Forty Years of Seismology and Seismic Service in the U. S. S. R.: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 11, p. 21-30, 1957 (Geophysical Abstracts 172-21).

116. Savarenskiy, Ye. F. and Kirnos, D. P., Elements of Seismology and Seismometry, Moscow, 1955 (Geophysical Abstracts 143-12373).

117. Pasechnik, I. P., Verbatum Record of the Fifth Meeting, Technical Working Group 2, Conference on the Discontinuance of Nuclear Weapon Tests, U. S. Department of State, p. 51, November 30, 1959.

118. Rustanovich, D. N., Some Problems of the Investigation of the Seismic Activity of the Ashkhabad Region: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, p. 9-21, 1957 (Geophysical Abstracts 169-44).

119. Sultanov, F. S., Discovery of Azimuthal Anomalies and Their Causes in the Region Explored by the Shemakha Seismic Expedition of 1953: Doklady AN, Azerbaydzhanskoy SSR, vol. 13, p. 623-628, 1959 (Geophysical Abstracts 172-237).

120. Sultanov, F. S., Sultanova, Z. Z., Alieva, S. M., A Small-Size Seismic Station: Doklady AN, Azerbaydzhaniskoy SSR, vol. 15, p. 123-127, 1959.

121. Beloussov, V. V., and Gzovskiy, M. V., Tectonic Conditions and Genesis of Earthquakes: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 25 (152), p. 25-35, 1954 (Geophysical Abstracts 160-117).

122. Gotsadze, O. D., Keylis-Borok, V. I., Kirillova, I. V., Kogan, S. D., Kukhtikova, T. I., Malinovskaya, L. N., and Sorskiy, A. A., An Investigation of the Mechanisms of Earthquakes: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 40 (166), p. 1-148, 1957 (Geophysical Abstracts 172-38).

123. Keylis-Borok, V. I., and Malinovskaya, L. N., The Dislocations of the Foci of Weak Earthquakes in Northern Tien-Shan: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 3, p. 176-182 (English Translation), 1957.

124. Egyed, L., The Mechanism of Production of Deep Earthquakes: Byulleten' po Seysmologii, AN, SSSR, no. 6, p. 89-95, 1957 (Geophysical Abstracts 173-82).

125. Kogan, S. D., The Dynamic Parameters of the Foci of Deep Earthquakes: Vestnik AN, U. S. S. R., 1954.

126. Kogan, S. D., Study of the Mechanism of Deep Earthquakes: Doklady AN, SSSR, vol. 99, no. 3, p. 385-388, 1954 (Geophysical Abstracts 161-103).

127. Rezanov, I. A., The Askhabad Earthquake of 1948 and Its Geological Background: Bull., Acad, Sci., U. S. S. R., Geophysics Series, no. 6, p. 407-413, 1958 (Geophysical Abstracts 175-32).

128. Gzovskiy, M. V., Tectonophysical Foundation of Geological Seismicity Criteria: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 2, p. 15-35, 1957.

129. Savarenskiy, Ye. F., and Nenilina, V. S., How Geologic Heterogeneities Can Be Accounted for When Locating the Focus of an Earthquake: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 1, p. 17-30, 1955 (Geophysical Abstracts 160-86).

130. Bonchkovskiy, V. F., Deformation of the Earth's Surface, Preceding and Accompanying a Catastropic Earthquake: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 9, p. 644-645, 1958.

131. Ostrovskiy, A. Ye., Slow Movements of

the Earth's Crust During Violent Earthquakes: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 1, p. 49-45, [?], 1955 (Geophysical Abstracts 168-37).

132. Gurevich, G. I., The Nature of Slow Movements Related to Earthquakes: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 31 (158), p. 135-154, 1955 (Geophysical Abstracts 165-38).

133. Gzovskiy, M. V., Mechanism of Formation of Complex Tectonic Faults: Razvedka i Okhrana Nedr, no. 7, p. 1-14, 1956.

134. Gzovskiy, M. V., Modeling of the Tectonic Fields of Stresses and Ruptures: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 6, p. 527-545, 1954 (Geophysical Abstracts 160-181).

135. Yanovskaya, T. B., Investigations of Displacement Fields in Surface Waves from Earthquake Foci with Assumed Parameters: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, p. 114 (Candidate's Dissertation), 1959.

136. Kirillova, I. V., The Periodicities of Destructive Earthquakes in the Caucasus and Turkey: Doklady AN, SSSR, vol. 115, no. 4, p. 771-773, 1957 (Geophysical Abstracts 172-35).

137. Gamburtsev, G. A., Present State and Outlook of Studies on the Forecasting of Earthquakes: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 1, p. 7-14, 1955 (Geophysical Abstracts 168-34).

138. Savarenskiy, Ye. F., Beloussov, V. V., Gzovskiy, M. V., Gubin, I. Ye., Kalashnikov, A. G., et al. Problems of Predicting Earthquakes: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 25 (152), 208 p., 1954.

139. Kondorskaya, N. V., Regional Peculiarity of Travel-time Curves of Seismic Waves: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 7, p. 67-86, 1957.

140. Kondorskaya, N. V., Corrections to the Jeffries-Bullen Travel-time Tables: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 6, p. 71-75, 1957 (Geophysical Abstracts 173-85).

141. Vvedenskaya, N. A., and Vogel', A. A., Epicentral Map of Northern Tien-Shan: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 2, p. 159-175, 1958.

142. Tvaltvadze, G. K., and Karsivadze, G. Ye., New Data on Distribution of Epicenters and Foci of Earthquakes in the Caucasus: AN, Gruzinskoy SSR, Trudy Institut Geofiziki, vol. 16, p. 165-175, 1957 (Geophysical Abstracts 176-35).

143. Riznichenko, Yu. V., The Mass Determination of the Co-ordinance of Local Earthquakes and of the Velocities of Seismic Waves in the Source Areas: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 4, p. 243-248, 1958 (Geophysical Abstracts 174-40).

144. Sultanova, Z. Z., An Evaluation of Errors in the Determination of Foci of Earthquakes When Using the Method of Time Fields: AN, Azerbaydzhan SSR, vol. 13, no. 5, p. 487-491, 1957 (Geophysical Abstracts 171-76).

145. Glivenko, Ye. V., Estimated Accuracy of Determining Earthquake Hypocenters: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 4, p. 363-368, 1959.

146. Kolosenko, M. N., Accounting of the Ellipticity of the Earth While Determining the Epicentral Distances: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, p. 67-70, 1958 (Geophysical Abstacts 175-44).

147. Savarenskiy, Ye. F., Differential Method in Seismology and the Angles of Emergence of Seismic Waves in Pulkova: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 1 (128), p. 11-29, 1948.

148. Savarenskiy, Ye. F., Angles of Emergence of Seismic Radiation and Some Allied Problems: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 15 (142), 109 p., 1952 (Geophysical Abstracts 151-14036).

149. Savarenskiy, Ye. F., Determination of Apparent Velocities of Seismic Waves in the Caucasus: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 2, p. 119-122, 1959.

150. Savarenskiy, Ye. F., and Aivazov, I. V., Determination of Azimuth and Emergence of Seismic Radiations: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 3, p. 253-259, 1959.

151. Savarenskiy, Ye. F., and Monakhov, F. I., Using the Azimuths and Angles of Emergence of Seismic Radiation for the Interpretation of Observations: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 1 (128), p. 39-55, 1948.

152. Savarenskiy, Ye. F., and Ragimov, Sh. S., Determination of the Velocity of Rayleigh Waves and of the Azimuth Toward the Epicenter According to Three Adjacent Stations: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 12, p. 866-869, 1958 (Geophysical Abstracts 177-68).

153. Gal'perin, Ye. I., Azimuthal Method of Seismic Observations: Moscow, 80 p., 1955.

154. Glivenko, Ye. V., On Exchange and Reflected Waves on Azimuthal Seismograms of Earthquakes in the Garm Oblast: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, 1960.

155. Solov'yev, S. L., and Shebalin, N. V., Determining the Intensity of an Earthquake from Surface Wave Ground Displacements: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 7, p. 102-108, 1957.

156. Arkhangel'skaya, V. M., Use of Surface Wave Recording in the Interpretation of Seismograms: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 6, p. 81-88, 1957 (Geophysical Abstracts 173-52).

157. Monakhov, F. I., and Dobilkina, N. A., The Structure of Microseisms: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 8, p. 537-541, 1958 (Geophysical Abstracts 176-291).

158. Savarenskiy, Ye. F., Lysenko. L. M., Kompanets, M. V., Microseisms in the Lake Issuk-Kul' as Observed by the Seismic Station at Rybach'e: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 8, p. 583-585, 1958.

159. Veshnyakov, N. V., Some Errors Connected with the Determination of the Azimuth of Microseisms by the Tripartite New Method: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 8, p. 586-588, 1958 (Geophysical Abstracts 176-288).

160. Rykunov, L. N., and Prosvirin, N. M., Distortions of the Azimuths of a Source of Microseisms, Caused by Conditions of Their Propagation: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 8, p. 589-591, 1958 (Geophysical Abstracts 176-289).

161. Solov'yev, S. L., Chronicle: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 3, p. 240-241, 1958.

162. Brekhovskikh, L. M., On Tsunamis and Observations of Very Distant Propagation of Sound in the Ocean: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 2, p. 8-11, 1956 (Geophysical Abstracts 166-70).

163. Savarenskiy, Ye. F., The Problem of Tsunamis: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 2, p. 3-7, 1956 (Geophysical Abstracts 166-71).

164. Keylis-Borok, V. I., Determination of the Dynamic Parameters of a Focus: AN, SSSR, Trudy Geofizicheskogo Instituta, vol. 9, (136), p. 3-19, 1950 (Geophysical Abstracts 146-12935).

165. Keylis-Borok, V. I., Graphic Determination of Dynamic Parameters of an Earthquake Focus: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 6, p. 11-27, 1951 (Geophysical Abstracts 148-133330).

166. Keylis-Borok, V. I., Theory of Waves Due to Displacements: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 4, p. 26-35, 1957 (Geophysical Abstracts 170-72).

167. Gotsadze, O. D., Keylis-Bork, V. I., Kirillova, I. V., Kogan, S. D., Kukhtikova, T. I., Malinovskaya, L. N., Sorskiy, A. A., Investigations of the Mechanisms of Earthquakes: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 40 (166), 148 p., 1957.

168. Keylis-Borok, V. I., Estimation of the Displacement in an Earthquake Source and of Source Dimensions: Anali Geofisica, vol. 12, no. 2, p. 205-214, 1959 (Geophysical Abstracts 179-73).

169. Keylis-Borok, V. I., Study of Earthquake Mechanism: Publications of the Dominion Observatory, Ottawa, vol. 20, no. 2, p. 279-294, 1957.

170. Kogan, S. D., Dynamic Parameters of Deep Earthquake Foci: AN, SSSR, Trudy Geofizicheskogo Instituta, vol. 30 (157), p. 30-82, 1955.

171. Kogan, S. D., Determining Parameters of Earthquake Foci, Which Are Approximately Equivalent to a Combination of Sources: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 5, p. 584-594, 1956 (Geophysical Abstracts 166-82).

172. Shebalin, N. V., The Relationship Between Intensity and Magnitude of Earthquakes with Respect to Focal Depth:

Byulleten' Soveta po Seismologii, AN, SSSR, no. 6, p. 122-126, 1956 (Geophysical Abstracts 173-62).

173. Bune, V. I., The Classification of Earthquakes According to the Energy of the Elastic Waves Radiating from the Focus: Doklady AN, Tadzhik SSR, vol. 14, 1955 (Geophysical Abstracts 168-27).

174. Solov'yev, S. L., On the Classification of Earthquakes According to the Magnitude of the Energy: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 30 (157), 1955 (Geophysical Abstracts 166-76).

175. Savarenskiy, Ye. F., The Study of Seismicity in the U. S. S. R.: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 6, p. 16-18, 1957 (Geophysical Abstracts 173-35).

176. Gorshkov, G. P., General Survey of Seismicity of the Territory of the U. S. S. R.: Travaux, Series A, vol. 19, p. 257-259, 1956 (Geophysical Abstracts 170-47).

177. Krestnikov, V. N., The Correlation of Geological and Seismic Phenomena in the Tien-Shan: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 3, p. 119-144 (English translation), 1957 (Geophysical Abstracts 171-53).

178. Gzovskiy, M. V., Krestnikov, V. N., Nersesov, I. L., Reisner, G. I., A comparison of Tectonics and Seismicity in the Garm Region, Tadzhik SSR, Parts I and II: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 8, p. 550-559, and no. 12, p. 840-844, 1958.

179. Kondorskaya, N. V., and Postolenko, G. A., Seismic Activity of the Kurile-Kamchatka Region During 1954 and 1956: Bull., Acad. Sci., U. S. S. R., no. 9, p. 646-649, 1958 (Geophysical Abstracts 176-42).

180. Bune, V. I., The Study of the Seismicity of the Tadzhik SSR and on the Activity of the Seismological Institute of the Academy of Science of the Tadzhik SSR on the Problem of Forecasting Earthquakes: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 1, p. 15-30, 1955 (Geophysical Abstracts 168-35).

181. Puchkov, S. V., Fundamentals of a Complex Method of Zoning: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, p. 61-65, 1958 (Geophysical Abstracts 175-45).

182. Gubin, I. Ye., Seismic Zoning in Southwestern Turkmenia: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 3, 1954.

183. Beloussov, V. V., Contribution to the Problem of Seismic Zoning Methods: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 3, 1954.

184. Gorshkov, G. P., Concerning a Map of Seismic Regionalization of the Territory of China: Doklady Vysshey Shkoly, Geol.-Geog. Nauki, no. 2, p. 25-32, 1958 (Geophysical Abstracts 177-53).

185. Problems of Engineering Seismology, Part I: AN, SSSR, Trudy Instituta Fiziki Zemli, no. 1 (168), 129 p., 1958.

186. Problems of Engineering Seismology, Part II: AN, SSSR, Trudy Instituta Fiziki Zemli, no. 5 (172), 192p., 1959.

187. Savarenskiy, Ye. F., Remarks on the Importance of Ground Conditions for Seismic and Clinometric Observations: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 22 (149), p. 102-110, 1954 (Geophysical Abstracts 164-69).

188. Kats, A. Z., and Puchkov, S. V., Action of Seismic Waves on Structures: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 3 (157), p. 226-239, 1955.

189. Puchkov, S. V., On the Limiting Intensity of Earthquakes on Basement Rock: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 8, p. 920-926, 1956 (Geophysical Abstracts 168-25).

190. Nazarov, A. G., Engineering Analysis of Seismic Forces, AN, Armyanskoy SSR, 2nd Edition, 285 p., 1959.

191. Nazarov, A. G., Equations of the Theory of Earthquake Resistance with a Dissipation of Energy Taken into Account: Doklady AN, Armyanskoy SSR, vol. 18, no. 3, p. 69-74, 1954 (Geophysical Abstracts 164-52).

192. Karapetyan, B. K., A Method of Determining Reduced Seismic Accelerations: Izvestiya AN, Armyanskoy SSR, Seriya Fizicheskaya i Matematika, vol. 8, no. 1, p. 41-47, 1955.

193. Medvedev, S. V., Dependence on Seismic Effects on the Phases of the Natural Oscillations of Structures: AN, SSSR, Trudy Geofizicheskogo Instituta, vol. 36 (163), p. 80-113, 1956 (Geophysical Abstracts 168-23).

194. Medvedev, S. V., Effect of the Forces of Internal Friction on the Oscillations of Buldings in the Case of Earthquakes: AN, SSSR, Trudy Geofizicheskogo Instituta, vol. 36 (163), p. 114-126, 1956 (Geophysical Abstracts 168-25).

195. Sadovskiy, M. A., The Simplest Method for Determining the Seismic Danger of Mass Explosions, Moscow, 29 p., 1946.

196. Kukebayev. M. M., The Studies of Earthquake-proof Construction in the Kazakh SSR: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 3, p. 183-190 (English translation), 1957.

197. Biryukov, V. V., Experience in the Design and Construction of Buildings at Alma Ata: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 3, p. 191-201 (English translation), 1957.

198. Bukhovstov, N. B., Stress Analysis of Building During Earthquakes, Based on Modern Methods of Laying Out Structures for Earthquake Resistance: Byulleten' Soveta po Seysmologi, AN, SSSR, no. 3, p. 202-222 (English translation), 1957.

199. Levin, B. W., Origin and Composition of the Earth: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 11, p. 11-20, 1957 (Geophysical Abstracts 155-15108).

200. Ulomov, V. I., Some Peculiarities of the Structure of the Earth's Crust in Central Asia, Based on Recordings Made by Powerful Explosions: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, 1960.

201. Andreyev, S. S., A Study of the Plutonic Structure of the Earth's Crust Using PS Exchange Waves Recorded During Earthquakes: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, p. 22-31, 1957.

202. Karapetyan, N. K., Study of the Earthquakes and Structure of the Earth's Crust of the Little Caucasus: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 4, p. 384, 1954.

203. Treskov, A. A., The Results of Determining the Thickness of the Earth's Crust from Observations of Distant Earthquakes: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 6, p. 76-80, 1957 (Geophysical Abstracts 173-247).

204. Shirokova, Ye. I., Certain Data on the Character of the Change of Velocities of the Upper Layer of the Earth's Mantle: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 8, 1959 (Geophysical Abstracts 179-255).

205. Bugayevskiy, G. N., On the Ouestion of the Structure of the Earth's Mantle: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 6, p. 63-66, 1957 (Geophysical Abstracts 173-242).

206. Vvedenskaya, A. V., and Balakina, L. M., Certain Peculiarities in the Displacement Field of Longitudinal and Transverse Waves Propagating Through the Earth's Mantle: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 6, p. 59-62, 1957 (Geophysical Abstracts 173-245).

207. Magnitskiy, V. A., The Nature of the Intermediate Layer of the Earth's Mantle at Depths of 400-900 km: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 6, p. 700-703, 1956 (Geophysical Abstracts 166-241).

208. Rykunov, L. N., A Study of the Character of Diminution of Amplitudes of Waves in the Shadow Zone of the Earth Model: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 10, p. 732-777, 1957 (Geophysical Abstracts 172-52).

209. Gurvich, I. I., Seismic Prospecting: Moscow, 343 p., 1954.

210. Gamburtsev, G. A., Riznichenko, Yu. V., Berzon, I. S., Yepinat'eva, A. M., Pasechnik, I. P., Kosminskaya, I. P., Karus, Ye. V., Refraction-Correlation Method: Moscow, 234 p., 1952.

211. Berzon, I. S., High-Frequency Seismic Methods: Moscow, 302 p., 1957 (Geophysical Abstracts 175-357).

212. Kogan, S. D., Pasechnik, I. P., and Sultanov, D. D., Differences in Periods of Seismic Waves Stimulated During Underground Explosions and Earthquakes: Doklady AN, SSSR, vol. 129, no. 6, p. 1283-1286, 1959.

213. Dyachkova, A. Ya., and Sollogub, V. B., Tracing Faults by the Seismic Reflection Method in the Outer Zone of the Carpathian Arc: Razvedka i Okhrana Nedr, no. 8, p. 37-42, 1956 (Geophysical Abstracts 169-311).

214. Raykher, L. D., Detailed Study of Fault Displacements: Prikladnaya Geofizika, no. 16, 1957.

215. Starodubrovskaya, S. P., Experiences from an Attempt to Locate the Buried Faults Through the Dynamic Characteristics of Refracted Waves: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 5, p. 1-21, 1957 (Geophysical Abstracts 170-279).

216. Troyanskiy, V. T., On the Possibility of Investigation of Intrusive Rocks by Seismic Methods of Exploration: Razvedka i Okhrana Nedr, no. 2, p. 32-41, 1957 (Geophysical Abstracts 176-322).

217. Yoseliani, M. S., and Murusidze, G. Ya., The Question of Application of Seismic Methods of Prospecting to the Solution of Some Problems in Engineering Geology, AN Gruzinskoy SSR, Trudy Geofizicheskogo Instituta, vol. 16, p. 115-120, 1957 (Geophysical Abstracts 176-339).

218. Antsyferov, M. S., and Konstantinova, A. G., Analysis of Seismo-Acoustic Method with Two Eruptions of Coal and Gas Mines of the Donets Basin: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 34 (161), p. 243-268, 1956.

219. Tarkhov, A. G., Wave Propagation Properties in Open-Pit Mines: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 4, p. 358-363, 1955.

220. Baranov, Ye. G., Danchev, P. S., Ivanov, K. I., Mal'chonok, V. O., Pashkov, A. D., Khanukayev, A. N.: Photographic Study of Drilling and Blasting Processes: Moscow, 186 p., 1959.

221. Gamburtsev, G. A., Some New Methods of Seismological Investigations Appendix: Bull. Acad. Sci., U.S.S.R., Geophysics, Series, no. 12, p. 1-8, 1957 (Geophysical Abstracts 172-220).

222. Volin, A. P., and Rudakov, A. G., Exploratory Operations Using Seismic Transverse Waves: Prikladnaya Geofizika, no. 15, p. 53-82, 1956 (Geophysical Abstracts 169-292).

223. Gurvich, I. I., The Use of Non-Longitudinal Profiles in the Refracted Wave Method: Prikladnaya Geofizika, no. 16, p. 85-97, 1957 (Geophysical Abstracts 171-322).

224. Yepinat'yeva, A. M., Wave Propagation in Media with Small Differences in Velocities: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 2, p. 130-136, 1955 (Geophysical Abstracts 161-93).

225. Yepinat'yeva, A. M., Refracted Waves in Media Characterized by Small Velocity Differences: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 4, p. 303-322, 1955.

226. Khalevin, N. I., The Use of the Refraction-Correlation Method in Prospecting for Coal Deposits in the Eastern Slopes of the Urals: Ural Branch, Trudy AN, SSSR, no. 30, Geofiziki Sbornik no. 2, p. 116-120, 1957 (Geophysical Abstracts 174-347).

227. Tvaltvadze, G. K., and Murusidze, G. Ya., Experience with Application of the Refraction-Correlation Method to the Solution of Certain Geological Problems: AN, Gruzinskoy SSR, Trudy, Instituta Geofiziki, vol. 13, p. 139-147, 1954 (Geophysical Abstracts 176-338).

228. Yepinat'yeva, A. M., Test of Recording Low-Frequency Vibrations in Seismic Prospecting by the Refraction-Correlation Method: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 35 (162), p. 146-159, 1956.

229. Veytsman, P. S., Correlation of Seismic Waves in Seismic Depth Sounding of the Earth's Crust: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 12, p. 9-28, 1957 (Geophysical Abstracts 172-224)

230. Kovalev, O. I., A Low-Frequency Exploration Seismograph: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 7, p. 913-916, 1958 (Geophysical Abstracts 176-332).

231. Aksenovich, G. I., Gal'perin, Ye. I., and Zayonchkovskiy, M. A., Features of a Device for Seismic Depth Sounding and Results of Its Testing: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 2, p. 59-68, 1957 (Geophysical Abstracts 169-279).

232. Vasil'yev, Yu. I., Kovalev, O. I., and Parkhomenko, I. S., Study of the Crystalline Basement by the Refracted Wave Method Under Conditions of Partial Masking, Parts I and II: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 3, p. 175-182, and no. 5, p. 569-581, 1958, (no. 3-Geophysical Abstracts 174-332), (no. 5-Geophysical Abstracts 175-369).

233. Gamburtsev, G. A., and Berzon, I. S., High-Frequency Seismic Prospecting: Doklady AN, SSSR, vol. 101, no. 5, 1955 (Geophysical Abstracts 163-92).

234. Nikolayevskiy, A. A., Factors Changing the Character of Seismic Waves: Academiy Neftyanoy Promyshlennosti

Trudy, no. 2, p. 154-166, 1955 (Geophysical Abstracts 166-341).

235. Khalevin, N. I., The Question of Measurement of Velocity of Elastic Waves in Conditions of Natural Occurrence of Rocks: AN, SSSR, Ural Filial Grono-Geol. Inst., Trudy, no. 30, Geofiziki Sbornik, no. 2, p. 133-141, 1957 (Geophysical Abstracts 175-89).

236. Koryakin, Ye. D., Deep Structure of the Earth's Crust in the Region of the Atlantic Ocean: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 12, p. 860-865, 1958 (Geophysical Abstracts 176-233).

237. Gal'perin, I. Ye., and Kosminskaya, I. P., Features of the Methods of Deep Seismic Profiling at Sea: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 7, p. 475-483, 1958.

238. Brekhovskikh, L. M., Distribution of Sound in an Underwater Sound Channel: Doklady AN, SSSR, vol. 69, p. 157-160, 1949.

239. Zverev, S. M., Utilizing Recorded Sound for Determining Distances in Seismic Depth Sounding at Sea: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 4, p. 385-392, 1959.

240. Tsvetayev, A. A., Testing the Application of Air Explosions in Seismic Reflection Exploration: Prikladnaya Geofizika, no. 1, p. 82-87, 1945 (Geophysical Abstracts 135-10583).

241. Tsvetayev, A. A., Use of Compound Charges in Air Blasts Seismic Prospecting: Prikladnaya Geofizika, no. 5, 1948.

242. Vinogradov, S. V., Acoustic Observations in Mines of the Kizelov Coal Basin: Bull., Acad. Sci., SSSR, no. 6, p. 60-72, 1957 (Geophysical Abstracts 171-341).

243. Sagomonyan, Ya., One-Dimensional Soil Creeps with Spherical Cylindrical, and Plane Waves: Moscow State University, Fiziko-Matematicheskiye Nauk, no. 3, p. 131-137, 1958.

244. Tsvetayev, A. A., Methods of Grouping Seismic Instruments: State Technical Press, Moscow-Leningrad, 1952.

245. Veytsman, P. S., The Selection of Distances Between Seismometers in Grouping for a Purpose of Reducing Background Interferences: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 6, p. 48-54, 1952.

246. Ryabinkin, L. A., Principles of the Resolving Capacity of Adjustable Directed Reception of Seismic Waves: Prikladnaya Geofizika, no. 16, p. 3-36, 1957 (Geophysical Abstracts 172-226).

247. Voyutskiy, V. S., Multiple Geophones: Prikladnaya Geofizika, no. 14, p. 23-56, 1956 (Geophysical Abstracts 168-281).

248. Garasov, Yu. A., On the Selection of Parameters of the Group in Connection with the Grouping of Seismic Receivers: Izvestiya Vyssheto Ucheb. Zavedeniy, Neft i Gaz, no. 9, p. 23-29, 1958.

249. Garasov, Yu. A., On the Significance of Curvature of Travel-time Curves of the Reflected Wave on the Grouping of Geophones: Izvestiya Vyssheto Ucheb. Zavedeniy, Neft i Gaz, no. 3, p. 17-24, 1959.

250. Voyutskiy, V. S., and Slutskovskiy, A. I., Seismic Station with Velocity Filters: Prikladnaya Geofizika, no. 13, p. 131-142, 1955.

251. Voyutskiy, V. S., Slutskovskiy, A. I., and Vishnyakov, Ye. P., Field Tests of Seismic Station with Velocity Filters: Razvedochnaya i Promyslovaya Geofizika, no. 17, p. 21-32, 1957 (Geophysical Abstracts 179-383).

252. Napalkov, Yu. V., Construction of Directional Characteristics for Complex Grouping in Seismic Exploration: Prikladnaya Geofizika, no. 22, p. 25-53, 1959 (Geophysical Abstracts 179-375).

253. Isayev, V. S., The Theory of the Directional Effect of a Group of Seismometers in Case of Pulse Oscillations, Part I and II: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 6, p. 437-444 and no. 10, p. 710 and 717, 1958 (Geophysical Abstracts 175-353).

254. Gal'perin, Ye. I., Grouping of the First Kind and a Method for Obtaining Multi-Component Azimuthal Seismograms: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 9, p. 1-23, 1957 (Geophysical Abstracts 172-223).

255. Kosminskaya, I. P., Analysis of Zones of Interference of Seismic Waves: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 35 (162), p. 116-145, 1956 (Geophysical Abstracts 171-105).

256. Sorokin, L. V., Urison, V. O., Rayabinkin, L. A., and Kolitskiy, V. I., Textbook on Geophysical Methods of Surveying Oil Deposits: Moscow, 579 p., 1953.

257. Sorokin, L. V., et al., Handbook of Seismic Prospecting: 94 p., 1953.

258. Oblogina, T. I., Local Representation of Systems of Head and Shear Waves: Moscow State University, Vestnik, no. 1, p. 121-128, 1956 (Geophysical Abstracts 172-58).

259. Vasil'yev, Yu. I., Study of Alternating Refracted Waves in Seismic Prospecting: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 3, p. 30-55, 1957 (Geophysical Abstracts 170-281).

260. Khalevin, N. I., Evaluation of the Accuracy of Data Obtained by the Refraction Wave Method: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 8, p. 912-919, 1956 (Geophysical Abstracts 168-295).

261. Fillipov, A. F., An Approximate Evaluation of Reflected and Refracted Waves: Bull., Acad. Sci., U. S. S. R., no. 7, p. 1-16, 1957 (Geophysical Abstracts 175-82).

262. Kalenov, Ye. N., et al., General Course in Geophysical Methods of Prospecting for Oil and Gas Deposits: Moscow, Chapter 10 (p. 193-202), 1954.

263. Yepinat'yeva, A. M., Certain Questions of the More Precise Interpretation of Data Obtained from Simultaneous Use of Reflected and Refracted Waves: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 4, p. 231-348, 1954 (Geophysical Abstracts 160-83).

264. Glotov, O. K., Accounting for Refraction on Intermediate Discontinuities When Interpreting Travel-time Curves of Refracted and Reflected Waves: Prikladnaya Geofizika, no. 16, p. 114-129, 1957 (Geophysical Abstracts 171-330).

265. Priyma, V. I., Corrections of Travel-time Curves of Reflected Waves: Razvedochnaya i Promyslovaya Geofizika, no. 17, p. 12-19, 1957 (Geophysical Abstracts 179-362).

266. Yunusov, N. K., Introduction of Corrections for the Upper Layer Into the Travel-time Curves of Reflected Waves at the Eastern Border of the Russian Platform: Prikladnaya Geofizika, no. 17, p. 115-129, 1957 (Geophysical Abstracts 177-361).

267. Bogdanov, A. I., Procedures for Interpreting Longitudinal Travel-time Curves of Reflected Waves for Continuous Media: Akademiya Neftyanoy Promyshelnnosti Trudy, no. 3, p. 97-105, 1956 (Geophysical Abstracts 172-229).

268. Zav'yalov, V. D., and Timoshin, Yu. V., Travel-time Curves of Waves Reflected from Curved Interfaces and their Interpretation: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 2, p. 118-129, 1955 (Geophysical Abstracts 161-84).

269. Timoshin, Yu. V., and Zav'yalov, V. D., Solution of Direct and Reverse Problems of Seismic Prospecting for Refraction Along Curved Interfaces: Nauch. Zap. L'vovsk Politekhnik Instit., Seriya Neftoy, vol. 35, no. 6, 1955.

270. Radzhabov, M. M., Certain Problems of Interpretation of Single Longitudinal Travel-time Curves of Refracted Waves: AN, Turkmenia SSR, no. 4, p. 3-12, 1957 (Geophysical Abstracts 177-340).

271. Korovnichenko, Ye. G., Velocities and Depths Determined by Combined Use of the Travel-time Curves of Longitudinal and One of the Types of Transformed Refracted Waves: AN, Ukraine SSR, Institut Geologiya Nauk Trudy, Seriya Geofizicheskaya, no. 2, p. 120-129, 1958 (Geophysical Abstracts 174-333).

272. Radzhabov, M. M., Determination of the Boundary Velocities from Transverse Travel-time Curves of Refracted Waves, Part I: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 12, p. 870-877, 1958 (Geophysical Abstracts 177-341).

273. Radzhabov, M. M., Some Properties of Transverse Travel-time Curves of Refracted Waves: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 7, 1959.

274. Riznichenko, Yu. V., and Glukhov, V. A., On the Ultrasonic Impulse Method of Seismic Well Logging: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 11, 1956 (Geophysical Abstracts 168-288).

275. Karus, Ye. V., and Pasechnik, I. P., Study of Elastic and Absorbing Properties of Rock Formations in Their Natural Occurrence by Seismoacoustic Methods: Izvestiya AN, SSSR, Seriya

Geofizicheskaya, no. 6, p. 515-526, 1954.

276. Timoshin, Yu. V., The Graphic Method of Interpreting Isochronic Maps: Nauch. Zapiski L'vovsk Politekhnik Institut, Seriya Geofizicheskaya, vol. 46, no. 1, 1956.

277. Berzon, I. S., Approximate Method of Quantitative Interpretation of Charts of Isochronal Reflected Waves: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 3, p. 252-262, 1956 (Geophysical Abstracts 166-345).

278. Yepinat'yeva, A. M., and Mikhaylova, N. G., Determination of Different Types of Multi-Reflected Waves According to the Kinematic and Dynamic Characteristics: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 7, 1959 (Geophysical Abstracts 179-364).

279. Yepinat'yeva, A. M., and Ivanova, L.M.A., Application of High-Frequency Filtering for Suppression of Many Multiple Reflection Waves: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 3, p. 244-252, 1959 (Geophysical Abstracts 178-373).

280. Zvolinskiy, N. V., Multiple Reflections of Elastic Waves in a Layer: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 22 (149), p. 26-49, 1954 (Geophysical Abstracts 164-90).

281. Yepinat'yeva, A. M., On Summary Multiple Reflections: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 8, 1959 (Geophysical Abstracts 179-365).

282. Riznichenko, Yu. V., Seismic Velocities in Stratified Media: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 2, p. 153-171, 1953.

283. Berzon, I. S., Boundary Velocities in Some Metamorphic and Crystalline Rocks: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 2, p. 101-117, 1955 (Geophysical Abstracts 161-92).

284. Berzon, I. S., Effective Velocities in the Case of Continuous Variation with the Depth of the True Velocities of Seismic Waves: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 4, p. 299-302, 1955, (Geophysical Abstracts 163-95).

285. Puzyrev. N. N., The Measurement of Seismic Velocities in Drill Holes: Vses. Nauchno-Issled. Inst. Geofiz. Metodov Razvedki Trudy, no. 3, p. 1-81, 1957 (Geophysical Abstracts 177-350).

286. Petkevich, G. I., Determination of Seismic Boundaries in Well Velocities Surveys: AN, Ukrainskoy SSR, Dopovidi, no. 10, p. 1104-1109, 1958 (Geophysical Abstracts 176-328).

287. Mozzhenko, A. N., An Instrument for Seismic Well Logging: Razvedochnaya i Promyslovaya Geofizika, no. 29, p. 52-55, 1959 (Geophysical Abstracts 179-386).

288. Karus, Ye. V., and Tsukernik, V. B., An Ultrasonic Apparatus for Studying the Physical and Mechanical Properties of Rocks Intersected by a Drill Hole: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 11, p. 755-761, 1958.

289. Khalevin, N. I., On the Impulse-Interval Acoustic Logging: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 3, p. 211-215, 1958 (Geophysical Abstracts 174-339).

290. Ryazanova, Yu. V., Simplified Method of Calculating Effective Velocity According to Conjugate Points of the Reflected Wave Travel-time Curves: Razvedochnaya i Promyslovaya Geofizika, no. 17, p. 36-40, 1957.

291. Puzyrev, N. N., Effect of the Curvature of the Boundary in Determination of the Velocity Using Travel-time Curves and Reflected Waves: Prikladnaya Geofizika, no. 13, p. 53-62, 1955 (Geophysical Abstracts 165-339).

292. Puzyrev, N. N., Use of Numerical Methods of Averaging and Determining Velocities of Travel-time Curves on Reflected Waves: Prikladnaya Geofizika, no. 16, p. 60-84, 1957 (Geophysical Abstracts 172-227).

293. Murusidze, G. Ya., Determination of Average Velocities from Overtaking Travel-time Curves of Reflected Waves: AN, Gruzinskoy SSR, vol. 16, no. 2, p. 103-107, 1955 (Geophysical Abstracts 168-292).

294. Murusidze, G. Ya., Application of the Overtaking Travel-time Curves of Reflected Waves in Seismic Prospecting: AN, Gruzinskoy SSR, Institut Geofiziki Trudy, vol. 14, p. 91-102, 1955 (Geophysical Abstracts 176-317).

295. Gurvich, I. I., Determination of Effective Velocities by Means of Superposition of Reciprocal Travel-time Curves of Reflected Waves: Moskov. Geol. Razved. Inst. Trudy, vol. 26, p. 196-

203, 1954 (Geophysical Abstracts 173-344).

296. Lyakhovitskiy, F. M., Application of Layer Velocities for Construction of Geological Sections: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 8, p. 95-101, 1957 (Geophysical Abstracts 176-312).

297. Matveyev, A. K., and Martyanov, Ye. G., The Dependence of Ultrasonic Velocity in Coal on the Degree of Metamorphism: Doklady AN, SSSR, vol. 122, no. 3, p. 456-461, 1958 (Geophysical Abstracts 175-93).

298. Volarovich, M. P., and Parkhomenko, Ye. I., The Piezoelectric Effect in Rocks: Doklady AN, SSSR, vol. 99, no. 2, 1954.

299. Volarovich, M. P., and Parkhomenko, Ye. I., The Piezoelectric Effect in Rocks: Izvestiya AN, SSSR, no. 3, 1955.

300. Parkhomenko, Ye. I., A Static Method for Determining the Piezoelectric Moduli of Rocks: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 4, p. 116-120, 1957.

301. Volarovich, M. P., and Parkhomenko, Ye. I., Modeling the Relations Between Seismic Phenomena and Disturbances in the Electrical Field of Rocks Due to the Piezoelectric Effect: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, p. 90-92, 1959.

302. Kirnos, D. P., The Development of Instrumental Seismic Observations in Soviet Russia: Byulleten' Soveta po Seysmologii, AN, SSSR, no. 6, p. 9-15, 1957 (Geophysical Abstracts 173-100).

303. Kirnos, D. P., Some Problems of Instrumental Seismology, Vestnik AN, SSSR, no. 4, 1953.

304. Pasechnik, I. P., and Fedoseyenko, N. Ye., Experience of Modernizing the Type SVK and SGK Seismographs: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 12, 1959.

305. Moskvina, A. G., and Shebalin, N. V., Frequency Characteristics of the Pulkova Station Seismographs: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 11, 1953.

306. Kirnos, D. P., and Kondorskaya, N. V., Calculation of the True Values of the First Amplitudes of the Ground Motion with the Arrival of a Seismic Wave: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 12, p. 840-844, 1958.

307. Andreyev, S. S., and Shebalin, N. V., On the Use of Short-Period Seismographs for Distinguishing Converted Waves on the Records of Distant Earthquakes: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 7, p. 102-108, 1957.

308. Kharin, D. A., and Rulev, B. G., Electrodynamic Seismograph for Recording Large Displacements: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, p. 131-134, 1957 (Geophysical Abstracts 169-64).

309. Medvedev, S. V., Seismometer for Determining the Intensity of Earthquakes: AN, SSSR, Trudy Geofizicheskogo Instituta, no. 36 (163), p. 127-133, 1956 (Geophysical Abstracts 167-61).

310. Popov, I. I., A Short-Period Vertical Seismograph with Magnetic Restoring Force: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 6, p. 445-447, 1958 (Geophysical Abstracts 175-63).

311. Gamburtsev, G. A., and Gal'perin, Ye. I., Azimuthal Seismic Observations with Inclined Seismographs: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 2, p. 184-189, 1954 (Geophysical Abstracts 157-74).

312. Pasechnik, I. P., Azimuthal Four-Component Installation with Inclined Seismographs: Izvestiya AN, SSSR, no. 3, p. 285-289, 1956 (Geophysical Abstracts 165-66).

313. Veshnyakov, N. V., Seismic Extensometer: AN, SSSR, Trudy Seysmologicheskogo Instituta, no. 140, p. 107-111, 1948.

314. Belotelov, V. L., Veshnyakov, N. V., Zhilyaev, I. I., A Seismic Energy Meter: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 4, p. 427-431, 1959.

315. Rykov, A. V., A Photoelectric Device for Recording the Energy Flux of Seismic Waves: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, p. 153-158, 1959 (Geophysical Abstracts 177-73).

316. Slutskovskiy, A. I., Electrodynamic

Seismographs: Razvedochnaya i Promyslovaya Geofiziki, no. 13, p. 28-35, 1955 (Geophysical Abstracts 169-277).

317. Polshkov, M. K., and Bereza, G. V., Application of Broad-Band Apparatus in Seismic Exploration: Razvedochnaya i Promyslovaya Geofiziki, vol. 16, p. 63-67, 1956 (Geophysical Abstracts 179-378).

318. Groshevoy, G. V., and Pasechnik, I. P., Highly Sensitive MPS-1 Field of Seismograph for Recording Short-Period Components of Seismic Waves: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 10, p. 1211-1218, 1956 (Geophysical Abstracts 168-283).

319. Melamud, A. Ya., Transient Processes in Seismic Prospecting Apparatus: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 4, p. 267-274, 1958 (Geophysical Abstracts 173-349).

320. Mozzhenko, A. N., Preparation of 52 Channel Seismic Stations and 226 Channel SS-26-51 Stations: Razvedochnaya i Promyslovaya Geofizika, p. 20-28, 1955.

321. Priyma, V. I., A Combined Mixing Arrangement: Razvedochnaya i Promyslovaya Geofizika, no. 18, p. 16-26, 1957 (Geophysical Abstracts 179-376).

322. Groshevoy, G. V., Design and Calculation of Magnetic Systems for Geophysical Instruments: AN, SSSR, Trudy Geofizicheskogo Instituta, vol. 20 (147), p. 88-94, 1953.

323. Melamud, A. Ya., Khudzinskiy, L. L., Deinega, S. A., A Station for Intermediate Magnetic Recording of Seismic Waves: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 2, p. 128-137, 1959 (Geophysical Abstracts 177-356).

324. Gamburtsev, G. A., Optical Seismoinclinometers: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 4, p. 305-311, 1954 (Geophysical Abstracts 158-116).

325. Bonchkovskiy, V. F., and Namsara S., Precision of Inclinometers: AN, SSSR, Trudy Geofizicheskogo Instituta, vol. 22 (149), p. 3-18, 1954.

326. Bonchkovskiy, V. F., Instrument Measurements of the Slow Movements of the Earth's Surface: Vestnik Moscow University, no. 6, p. 93-95, 1955.

327. Bonchkovskiy, V. F., and Latynina, L. A., Linear-Rolling Strain Seismograph: Izvestiya AN, SSSR, Seriya Geofizicheskaya, no. 3, p. 275-277, 1955 (Geophysical Abstracts 162-214).

328. Bonchkovskiy, V. F., and Karmaleyeva, R. M., Effect of Fiber Torsion on the Readings of Pendulum Clinometers: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 9, p. 123-126, 1957.

329. Shakurov, P. F., Highly Sensitive Apparatus for Determination of the Inclination of the Earth's Surface and for Recording Seismic Waves: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, p. 102-103, 1959 (Geophysical Abstracts 177-74).

330. Pasechnik, I. P., and Fedoseyenko, N. Ye., An Electrodynamic Microbarograph with Recording Galvanometer: Bull., Acad. Sci., U. S. S. R., Geophysics Series, no. 1, p. 71-76, 1958 (Geophysical Abstracts 176-290).

331. Keylis-Borok, V. I., Interference of Waves in a Multi-layered Elastic Medium: in press in 1959.

Alphabetical Key, by Senior Author, of References as Numbered Above

MINERALOGY OF CLAYS FROM THE ODESSA COAST OF THE BLACK SEA[1]

By

Ye. F. Sidorenko[2]

• translated by Royer and Roger, Inc. •

ABSTRACT

A study was made of the clay belonging to the Upper Miocene (bluish-gray clay), Upper Pliocene (reddish-brown clay), Holocene and Pleistocene (loess-like clay) from the landslide district near Odessa. The investigation has shown that the clays of these three units are not monomineralic and that each one has features indicating the prevalence of hydromica or montmorillonite as the main rock-forming mineral. Thus, hydromica is dominant in the blue-gray clay, while montmorillonite prevails in those that are reddish-brown and loess-like. These deductions have been fully confirmed by calculation of the size of the basic cells. --auth.

***

Landslides of different shape and size often develop on the Black Sea Coast near Odessa. One such great landslide occured on July 19, 1957 at Odessa, in the vicinity of the 13th Bolshoy Fontan Station (fig. 1). It was investigated by L. N. Kudrin and this author, who concluded after their investigation, that there had been a collapse in the slide area.

Since landslides usually develop in stratified clay deposits, the author made a detailed mineralogical investigation of the clay at the site of the landslide on the supposition that this would, to some extent, help to understand the reasons for the occurrence of the landslide.

The stratigraphic section, taking into account the facies in the region of the landslide, is as follows, according to L. N. Kudrin (from top to bottom):

FIGURE 1. Photograph of landslide near the 13th Station of Bolshoy Fontan, July 20, 1957. Photograph by Chernoivanov S.

1. Holocene and Pleistocene. Loess-like loam, loess-like clay, fossil soils and loess. Thickness as much as 16 meters.

2. Upper Pliocene. Levantinian. Reddish-brown clay (deltaic and lacustrine facies).

---

[1] Translated from K mineralogii glin Odesskogo poberezhya chernogo more: Mineralogichesky sbornik, no. 13, 1959, p. 220-234.

[2] Lvov Ivan Franko State University.

Thickness as much as 6 meters.

3. Lower Pliocene. Lower Pontion. Odessa unit. Light gray limestone consisting of complete shells, mainly recrystallized (deposits of the upper part of the sublittoral zone, with low salinity). In certain places there are oolitic detrital limestones and marls. Thickness as much as 7 meters.

4. Upper Miocene. Meotisian. Light bluish-gray and light blue clay (sublittoral deposits). Visible thickness as much as 2 meters.

We have investigated samples of light bluish-gray clay from the Meotisian strata, reddish-brown clay from the Levantinian deposits, and Quarternary pale yellow, loess-like soils.

The granulometric composition of the clays studied (table 1) shows that the light bluish-gray clay generally consists of clay fractions (less than 0.001 mm) and silt-size particles; it could be considered a sandy to silty clay. The reddish-brown clay in general consists of clay particles and is a silty clay. The composition of loess-like soil also corresponds to the composition of the silty clay.

TABLE 1. Granulometric composition of clays studied

Number in order	Type of Clay	weight of sample in gm	Size of particles in mm: >0.6 weight in gm	>0.6 percent	0.6-0.2 weight in gm	0.6-0.2 percent	0.2-0.056 weight in gm	0.2-0.056 percent	0.056-0.01 weight in gm	0.056-0.01 percent	<0.01 percent
1	Light bluish-gray clay	50	1.600	3.2	1.500	3.0	10.500	21.0	5.300	10.6	62.20
2	Reddish-brown clay	100	0.050	0.05	0.200	0.2	4.700	4.7	9.600	9.6	85.45
3	Loess-like clay	100	0.040	0.04	0.080	0.08	3.450	3.45	31.150	31.15	65.28

TABLE 1. Granulometric composition of clays studied (concluded)

Number in order	Type of Clay	Carbonates, in percent	weight of sample for separation in gm	Distribution of silt Fraction 0.2-0.056 mm according to specific gravity: Heavy weight in gm	Heavy percent	Light weight in gm	Light percent	Granulometric type of clay
1	Light bluish-gray clay	3.0	5.000	0.003	0.06	4.997	99.94	Sandy silty clay
2	Reddish-brown clay	5.6	4.700	0.010	0.21	4.690	99.79	Partly silty clay
3	Loess-like clay	7.9	3.450	0.007	0.20	3.443	99.80	Silty clay

THE LIGHT BLUISH-GRAY CLAY

The silty clay of the Meotisian deposits is light bluish-gray with a touch of green. It is uniform in appearance and plastic; in places thin veins of brown iron oxides are present. The rock effervesces in hydrochloric acid.

Microscope study shows that the texture of the rock is fine-grained pelitic. The ground mass consists of the finest micaceous clay flakes in a felt-like texture through which angular quartz grains of irregular shape are scattered. Carbonate material is not present in noticeable concentrations in the rock, but is uniformly distributed as pelitomorphic particles. In a randomly oriented aggregate of the groundmass one can here and there see small areas with oriented clay particles.

According to granulometric composition (see table 1) the rock consists of finely dispersed sand and silt. The carbonate content is 3 percent by volume. The refractive indices of the aggregates of oriented particles <0.001 mm (which form elongated, nearly colorless anisotropic flakes) are: $\gamma=1.578$; $\omega=1.558$; $\gamma-\omega=0.020$. These refractive indices are characteristic of hydromica, as well as of montmorillonite with an admixture of hydromica.

In the geochemical and X-ray laboratory of Lvov University absorption spectrum curves were obtained by means of an SF-2M self-registering spectro-photometer.

The absorption spectrum curve for the sus-

pension of light bluish-gray clay colored with Mg (MT) (fig. 2) has a clearly marked "doublet" maximum near 575mμ and another low "ionic" maximum near 680mμ. On the addition of KCl, the "doublet" maximum decreases considerably and shifts to the long-wave portion near 618mμ, after which the "ionic" maximum becomes greater than the "doublet". The curve obtained belongs to the K (1) type and the HM type (transition to montmorillonite), and shows that montmorillonite is present in the suspension of light bluish-gray clay, in addition to the hydromica.

The photograph taken with an electron microscope (fig. 3) shows thin semi-transparent isometric scales and particles which characterize hydromica and beidellite. The same photograph also shows small lumps with diffuse contours resembling montmorillonite. There are also large opaque particles, some of which have sharp contours, which might be unsaturated small lumps of clay or quartz.

Three endothermic effects are discernible on the heat curve (fig. 4) for the clay fraction less than 0.001 mm: 1) a clearly marked effect at 140°C; 2) an effect from 500 to 600°C, and 3) an effect changing to the exopeak between 900 and 1000°C.

The dehydration curves (fig. 5) complement the heat curves and show that we are dealing here both with an

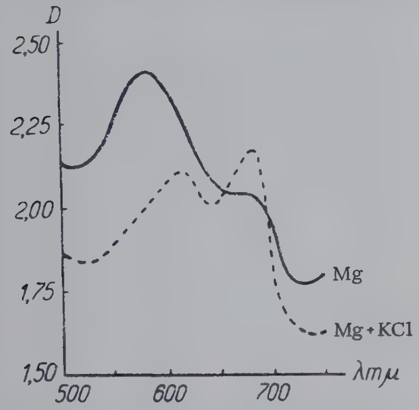


FIGURE 2. Absorption spectrum curves for suspension of light bluish-gray clay

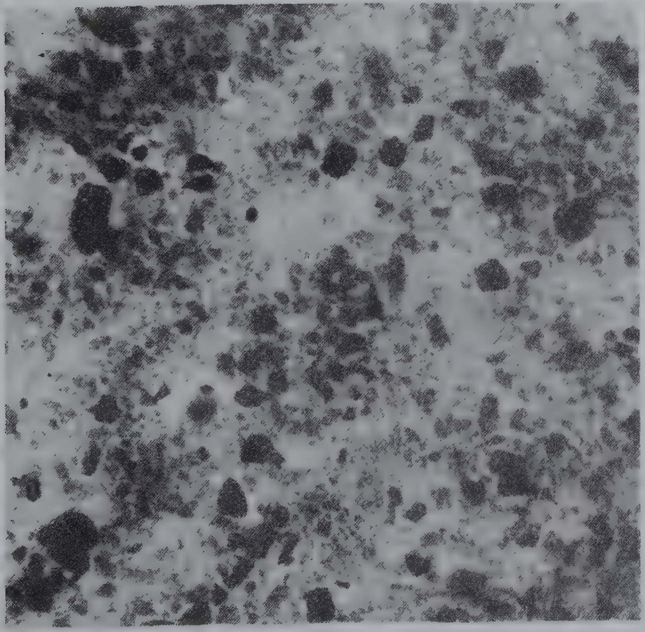


FIGURE 3. Photograph of light bluish-gray clay taken under electron microscope (12,000 x)

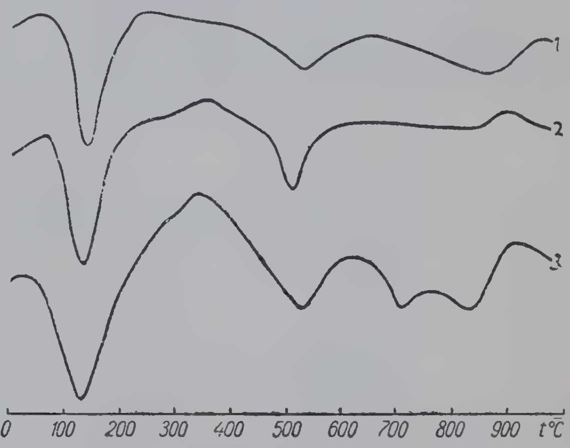


FIGURE 4. Heating curves for Odessa clays.
1- Light bluish-gray clay; 2- loess-like clay; 3- reddish-brown clay.

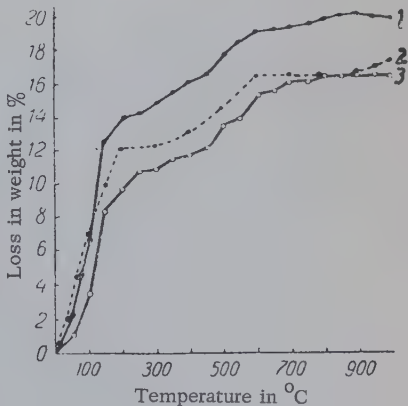


FIGURE 5. Dehydration curves for Odessa clays
1 - Reddish-brown clay; 2 - light bluish-gray clay; 3 - loess-like clay.

endothermic effect of the montmorillonite type as well as that of hydromica: The maximum quantity of water is given off before 200° C, and later at 450° to 600° C; some loss of weight (up to 1 percent) is also noticeable at 800 to 900° C.

The swelling of the clay was measured by T. M. Polonsky in the laboratory of the Department of Physical Chemistry at Lvov University, using a modified form of Freyndlikh's [Freindlich's ?] device. In this device, water absorption prior to the swelling is not prevented. The swelling of the clay (fig. 6) takes place, for practical purposes, in 19 hours and gives a

By this system of computation, the light blue clay (table 2) proved to be closest to hydromica in chemical composition. On this basis the analysis was computed for oxygen 12.

The X-ray data (table 3) confirms that hydromica predominates in bluish-gray clay and that quartz and montmorillonite are also present.

The hydrogen index of the clays was determined potentiometrically, using a glass electrode, by the water suspension method by T. M. Polonsky; the ratio of water to clay was 2.5:1. This method was recommended by the Inter-

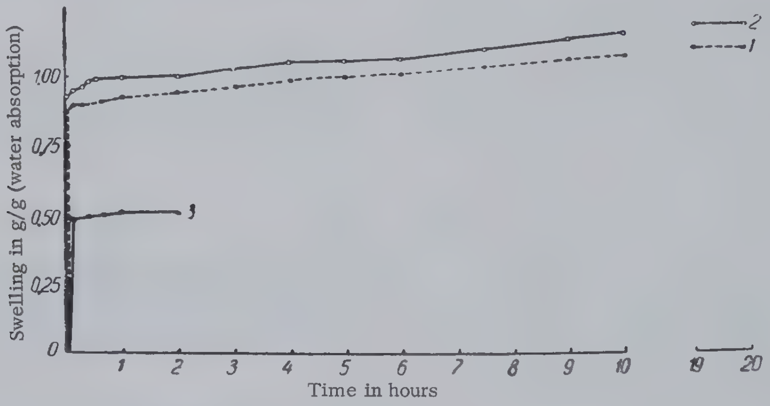


FIGURE 6. Swelling curves for Odessa clays
1 - light bluish-gray clay; 2 - reddish-brown clay; 3 - loess-like clay.

a value of 1.8 g/g or, taking into consideration the quantity of water absorbed, 0.4 g/g, the total quantity of water is equal to 0.78 g/g (78 percent); this shows that the clay swells by a factor of less than 2.

A chemical analysis of the clay fraction <0.001 mm was made by B. M. Turkevich in the laboratory of the Institute of Geology of Mineral Deposits of the Academy of Sciences of the Ukrainian SSR. When computing the chemical composition, we conditionally estimated the ignition loss as a quantity of water (H_2O). The carbonates were removed during preparation of the clay fraction less than 0.001 mm. Whenever P_2O_5 and sulphur were present, they were removed by the addition of the correct quantities of calcium and iron oxide necessary to form apatite and pyrite. Since our clays are not monomineralic the conversion was made conditionally. Whenever the chemical analysis showed more than 3 percent K_2O (taking into account the SiO_2 and H_2O content), we assumed the predominance of hydromica in the clay and made computations on the basis of hydromica, but when the H_2O content was less than 3 percent, we made computations on the basis of montmorillonite.

national Society of Soil Scientists. The pH value of light bluish-gray clay was determined to be 7.37.

THE REDDISH-BROWN CLAY

This clay is uniform in appearance. In a dry condition it is stony and dense. Its fracture is uneven. When cut in a moist state it has a lustrous surface. Cracks and a nutty texture are developed during drying (it breaks into different size nut-like lumps). Concretions of gypsum are present in the cracks. After drying, the fraction less than 0.001 mm greatly diminishes in volume and splits into narrow strips.

Under a microscope with parallel nicols, the clay mass is translucent with a dirty-brown and red-brown hue due to the admixture of colloidal iron oxide. With crossed nicols, an aggregate interference tint is seen. Grains of quartz and microcline are scattered through the clay.

The granulometric composition of the reddish-brown clay (table 1) shows that it is a finely-dispersed silty clay. In the heavy fraction the following minerals are present: rutile, zircon, leucoxene, apatite, anatase, tourmaline,

TABLE 2. Chemical analysis of light bluish-gray clay recalculated for hydromica

(Fraction <0.001 mm)

Oxides	Weight in percent	Number of molecules	Number of oxygen atoms	Number of oxygen atom computed for 12	Atomic Number of cations	Number of cation atoms
SiO_2	50.62	843	1686	7.00	843	3.5
TiO_2	0.87	011	022	0.1	011	0.05
Al_2O_3	20.18	198	594	2.5	396	1.65
Fe_2O_3	8.02	050	150	0.63	100	0.42
CaO	0.58	011−003=008	008	0.03	008	0.03
MgO	2.48	063	063	0.26	063	0.26
K_2O	3.67	039	039	0.16	078	0.33
Na_2O	0.13	002	002	0.01	004	0.02
P_2O_5	0.17	001	—			
H_2O-	7.57	422	422 } 315	1.31		2.62
H_2O+	4.34 } 6,39	356	356			
Ignition loss	2.05					
Total	100,68		3342 − 463	12.00		
	Common denominator: 2879 : 12 = 240					

Using formulas:

$$y = \frac{2(A - C - 11D)}{21}; \qquad X = A - 12D - 13y,$$

where $A = 3342$, $C = 778$, $D = 90$;

$$y = \frac{2(3342 - 778 - 11.90)}{21} = 150;$$

$$X = 3342 - 12.90 - 13.150 = 313;$$

$$X + y = 463; \qquad C - (X + y) = 778 - 463 = 315.$$

$$X - 313 : 240 = 1.3;$$

$$y - 150 : 240 = 0.62.$$

Crystal chemical formula:

$$(K_{0.33}Na_{0.02}Ca_{0.03}H_3O_{0.62})_{0.99}(Mg_{0.26}Al_{1.20}Fe_{0.42})_{1.88}(OH)_2[Al_{0.45}Si_{3.5}Ti_{0.05}O_{10}] \cdot 1.3H_2O$$

$$SiO_2 : R_2O_3 = 3.4$$

TABLE 3. X-ray data of clays studied

Number in order	Light bluish-gray clay		Reddish-brown clay		Loess-like clay		Quartz			Hydromica			Montmorillonite		
	I	$\frac{d}{n}$	I	$\frac{d}{n}$	I	$\frac{d}{n}$	$hkil$	I	$\frac{d}{n}$	hkl	I	$\frac{d}{n}$	hkl	I	$\frac{d}{n}$
1	4	15.0	4	14.4	2	15.3	—	—	—	—	—	—	001	10	~15
2	2	9.8	4	9.8	2	9.8	—	—	—	002	8	10.6—10	—	—	—
3	3	—	—	—	2	8.0	—	—	—	—	—	—	002β	2	(~8.0)
4	—	—	1p	7.2	2	7.2	—	—	—	—	—	—	002	2	~7.5
5	10	4.5	8	4.5	5	4.4	—	—	—	110	8	4.49	110	10	4.44
6	2	4.2	2	4.3	6	4.2	1010	5	4.26	022	2	4.11	—	1	4.28
7	1	3.87	—	—	—	—	—	—	—	023	2	3.85	—	—	—
8	1	3.72	—	—	—	—	—	—	—	114	1	3.72	—	—	—
9	10	3.35	10	3.33	10	3.32	1011	10	3.34	006	6	3.31	—	—	—
10	2	3.19	2	3,19	2	3.19	—	—	—	—	2	3.043	—	—	—
11	2	2.998	1	2.993	1p	2.978	—	—	—	025	2	2.99	—	—	—
12	2	2.880	1	2.857	—	—	—	—	—	115	2	2.88	—	—	—
13	1	2.786	—	—	—	—	—	—	—	—	—	—	200β	3	(2.81)
14	—	—	2	2.702	—	—	—	—	—	—	—	—	—	—	—
15	9	2.570	9	2.567	8ш	2.561	—	—	—	$20\bar{2}$	10	2.570	200;130	8	2.570
16	—	—	2	2.497	—	—	—	—	—	—	—	—	020β; 110β	3	(4.89)
17	4	2.458	2	2.453	4	2.448	$11\bar{2}0$	4	2.456	$1\bar{3}\bar{3}$	4	2.44	—	—	—
18	4	2.382	2	2.384	2	2.377	—	—	—	133	6	2.38	—	—	—
19	2	2.282	1	2.277	4	2.274	$10\bar{1}2$	5	2.284	—	—	—	—	—	—
20	2	2.243	1	2.237	2	2.234	$11\bar{2}1$	2	2.234	$22\bar{1}$	6	2.24	—	—	—
21	1	2.193	1	2.195	1	2.176	—	—	—	223	2	2.190	—	—	—
22	5	2.129	3	2.126	5	2.120	$20\bar{2}0$	5	2.123	043	4	2.11	—	—	—
23	—	—	—	—	3	2.090	—	—	—	—	—	—	—	—	—
24	5	1.986	4ш	1.991	—	—	—	—	—	0.0.10	6	1.986	—	—	—
25	2	1.894	1p	1.888	1	1.886	—	—	—	—	—	—	141;008	1	1.88
26	6	1.816	6	1.816	6	1.812	1122	8	1.812	—	—	—	—	—	—
27	5	1.701	4p	1.699	—	—	—	—	—	—	—	—	300;225	6	1.708
28	5	1.669	4ш	1.669	—	—	—	—	—	1.3.10	7ш	1.655	310;	6	1.655

TABLE 3. X-ray data of clays studied (concluded)

Number in order	Light bluish-gray clay		Reddish-brown clay		Loess-like clay		Quartz			Hydromica			Montmorillonite		
	I	$\frac{d}{n}$	I	$\frac{d}{n}$	I	$\frac{d}{n}$	$hkil$	I	$\frac{d}{n}$	hkl	I	$\frac{d}{n}$	hkl	I	$\frac{d}{n}$
29	5	1.642	4p	1.646	—	—	—	—	—	312	5	1.642			
30	—	—	2	1.604	—	—	—	—	—	—	—	—	—	—	—
31	6	1.541	6	1.542	6	1.539	$21\bar{3}1$	8	1.537						
32	10	1.502	9	1.502	7ш	1.500	—	—	—	060	10	1.498	—	—	—
33	—	—	—	—	1	1.488	—	—	—	—	—	—	060	8	1.49
34	1	1.454	3	1.452	3	1.448	$11\bar{2}3$	3	1.450	—	—	—	—	—	—
35	—	—	2	1.420	—	—	—	—	—	—	—	—	—	—	—
36	2	1.380	2	1.382	—	—	$21\bar{3}2$	7	1.380	—	—	—	317; 332	—	1.38
37	5	1.311	4	1.374	8	1.371	$20\bar{2}3$	9	1.370	—	—	—	—	—	—
38	2ш	1.353	2	1.354	—	—	—	—	—	335	2	1.34	—	—	—
39	2ш	1.336	2	1.336	—	—	—	—	—	—	—	—	—	—	—
40	6ш	1.295	6ш	1.295	2	1.298	—	—	—	400	8	1.295	400	5	1.292
41	—	—	—	—	5	1.286	—	—	—	—	—	—	260	6	1.285
42	4ш	1.247	6ш	1.252	5	1.256	$30\bar{3}2$	4	1.253	—	—	—	—	—	—
43	—	—	—	—	1	1.240	—	—	—	0.0.16	4	1.24	170	4	1.24
44	2	1.221	2	1.229	2	1.226	$22\bar{4}0$	2	1.229	—	—	—	—	—	—
45	6	1.199	5	1.200	7	1.198	$21\bar{3}3$	4	1.199	—	—	—	—	—	—
46	6	1.180	6	1.182	8	1.180	$11\bar{2}4$	8	1.182	—	—	—	—	—	—
47	1	1.154	1	1.153	5	1.151	$31\bar{4}1$	6	1.154	—	—	—	—	—	—
48	—	—	2	1.129	—	—	—	—	—	080; 431	2	1.129	080. 350	—	1.124
49	—	—	1	1.113	—	—	$30\bar{3}3$	2	1.113	—	—	—	—	—	—
50	4	1.082	6	1.081	7	1.079	$31\bar{4}2$	8	1.082	—	—	—	—	—	—
51	1	1.064	2	1.064	3	1.062	$40\bar{4}0$	3	1.065	—	—	—	—	—	—
52	1	1.049	2	1.048	2	1.046	$10\bar{1}5$	8	1.045	—	—	—	—	—	—
53	2	1.036	4	1.035	5	1.033	$21\bar{3}4$	7	1.036	—	—	—	450	1	1.035
54	2	1.016	2	1.014	4	1.014	$22\bar{4}3$	5	1.017	—	—	—	—	—	—
55	2	1.008	—	—	—	—	—	—	—	—	—	—	—	—	—
56	—	—	—	—	5	0.989	$40\bar{4}2$ (α_1 1)	7	0.9876	—	—	—	—	—	—
57	—	—	—	—	4	0.987	duplicate α_2 2								

pyrite, muscovite, garnet, ilmenite, staurolite, epidote, hornblende, brown ironstone, and glauconite.

The refractive indices of the aggregates of oriented particles less than 0.001 mm are: $\gamma'=1.559$; $\omega'=1.540$; $\gamma'-\omega'=0.019$. The optic constants of the reddish-brown clay were determined both before and after oxalic acid treatment. The results were identical, which shows the presence of iron in a mechanical admixture. Compared to common montmorillonite, these indices are slightly higher; this appears to be due to the admixture of hydromica.

The absorption spectrum curves for the reddish-brown clay suspension can be classed as type M (1), which is characteristic of some montmorillonite clays. A maximum at about 570 β and a low maximum in the long-wave portion at about 680 β are observed on the curve.

The addition of KCl causes the maximum at about 570 β to disappear and the maximum at about 680 β to become intensified. To obtain absorption spectrum curves, the specimen of reddish-brown clay was treated with 3 percent oxalic acid to remove the iron oxide, the suspension being taken from clarified clay (fig. 7). This was the most likely reason for the difficulty in obtaining the Mg+KCl curve, since the suspension with Mg quickly settled on the addition of KCl.

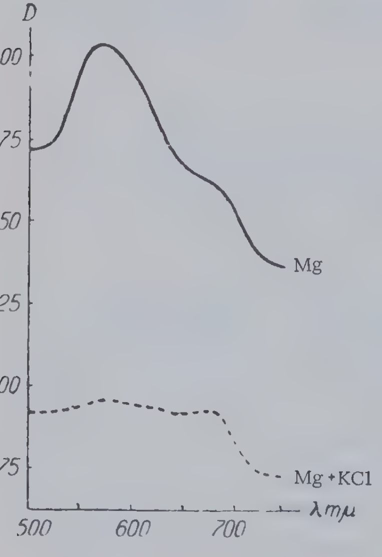


FIGURE 7. Absorption spectrum curves for suspension of reddish-brown clay

Through an electron microscope, the fraction <0.001mm is represented by three types of particles (fig. 8):

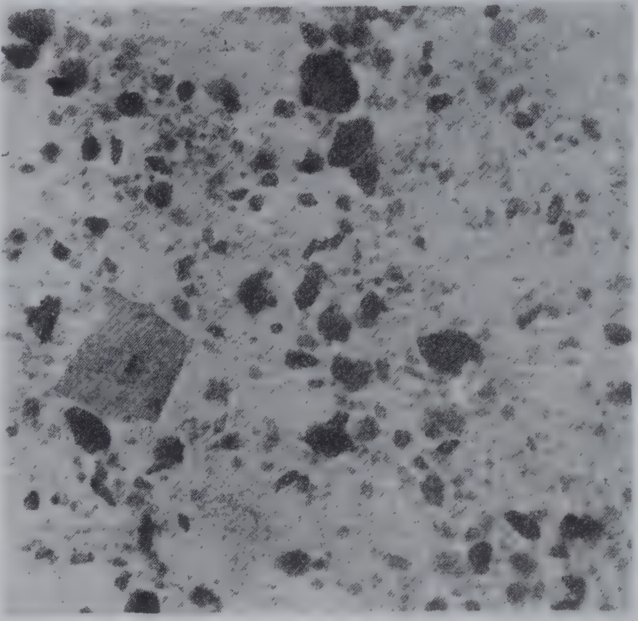


FIGURE 8. Photograph of reddish-brown clay taken under electronic microscope (12,000x)

1. Finely-dispersed semi-transparent isometric particles shaped with predominately diffuse contours. Aggregates of these particles can be observed in places.

2. Non-transparent particles with sharp contours. These are possibly quartz or iron oxide.

3. A smaller quantity of elongated semi-transparent flakes. The heat curves for reddish-brown clay (fig. 4) show three endothermic and two exothermic reactions, resembling the curve for montmorillonite. The dehydration curve (fig. 5) shows that the bulk of the water (14.2 percent) is given off below 200°C. The second portion of water (5.1 percent) is released below 600°, and a further 1.2 percent 900°. The swelling curves (fig. 6) show that the reddish-brown clay stops swelling after 19 hours. We have taken into consideration the fact that the absorbed water is partly consumed by absorption required to fill the pores of the dispersion phase and the volume between separate particles, and in the process of swelling itself. The total amount of water taken in by the reddish-brown clay, including water which is taken up in the absorption of 0.4 g/g of the solid phase, is equal to 0.85 g/g (85 percent). The data obtained have led T. M. Polonsky to class the Odessa clay as a slightly swelling clay (the volume of reddish-brown clay is only about doubled, while sodium bentonites can increase

their volume ten times or more).

Just before the chemical analysis was made, the fraction <0. 001 mm of reddish-brown clay was treated with oxalic acid until the mechanically admixed iron oxides were completely removed. The analysis was made by B. M. Turkevich from the treated clarified clay. The free R_2O_3 content=4. 35 percent.

A determination of the quantity of water in the rock itself was also made, and gave a volume of 17. 27 percent. The results of the analysis are given in Table 4. They show that the

TABLE 4. Chemical analysis of reddish-brown clay recalculated for montmorillonite (fraction<0.001 mm)

Oxides	Weight in percent	Number of molecules	Number of oxygen atoms	Number of oxygen atoms computed for 12	Atomic number of cations	Number of cation atoms
SiO_2	49.52	825	1650	8.20	825	4.1
TiO_2	0.59	007	014	0.08	007	0.04
Al_2O_3	13.23	129	387	1.93	258	1.28
Fe_2O_3	4.02	025	075	0.38	050	0.26
FeO	0.12	001	001	0.01	001	0.01
MnO	trace					
CaO	0.33	005	005	0.02	005	0.02
MgO	1.86	046	046	0.24	046	0.24
K_2O	1.49	016	016	0.08	032	0.16
Na_2O	0.76	012	012	0.06	024	0.12
P_2O_5	0.06	—				
H_2O-	20.10	1117	1117	1.00		2.00
H_2O+	8.10	450	450	201		
	100.18		3773 −1366 2407	12.00		

Common denominator: 2407 : 12 =201

To determine the absorption water we use the formula:

$$X=\frac{2mC-\kappa A}{2m-K}=\frac{2\cdot 12\cdot 1567-2\cdot 3773}{2\cdot 12-2}=1366;$$

$$C-X=1567-1366=201; \qquad X=1366:201=6.8.$$

Crystal chemical formula:

$$(K_{0.16}Na_{0.12}Ca_{0.02}Mg_{0.24}\overset{'''}{Fe}_{0.26}\overset{''}{Fe}_{0.01}Al_{1.28}Ti_{0.04})_{2,13}(OH)_2[Si_4O_{10}]\cdot 6.8H_2O$$

$$SiO_2:R_2O_3=5.4$$

fraction less than 0.001 mm corresponds in its principal components to montmorillonite clay.

The pH value of reddish-brown clay is 7.86.

Lines of montmorillonite, hydromica, quartz and iron oxide were discovered on the X-ray in reddish-brown clay (table 3).

THE LOESS-LIKE CLAY

This clay is pale in color, has an earthy structure and is porous. It is uniform in appearance. It can easily be powdered between the fingers. When mixed with water, it readily forms a doughy mass; it effervesces vigorously with hydrochloric acid. In outcrops it forms stable vertical walls, which indicate considerable cohesion between the particles. The clay is riddled with vertical, branching, pipe-like pores. On the basis of its granulometric composition (table 1) the loess-like clay is a finely-dispersed silty clay. The carbonate content, computed by volume, is 7.9 percent. Magnetite was discovered in the magnetic fraction; ilmenite, tourmaline, hornblende, garnet, staurolite, leucoxene, epidote, chromite, ironstone and mica in the heavy electromagnetic fraction, and rutile, zircon, leucoxene, anatase and apatite in the heavy non-electro-fraction. The minerals of the light fraction generally consist of rounded and semi-rounded grains of quartz, mica, feldspar and chlorite.

The refractive indices of the aggregates of oriented particles in the fraction less than 0.001 mm are: $\gamma'=1.576$; $\omega'=1.561$; $\gamma'-\omega'=0.015$.

These refractive indices are close to those of hydromica, but they are also close to those of montmorillonite with an admixture of hydromica.

The absorption spectrum curves for the fraction less than 0.001 mm (fig. 9) are close to

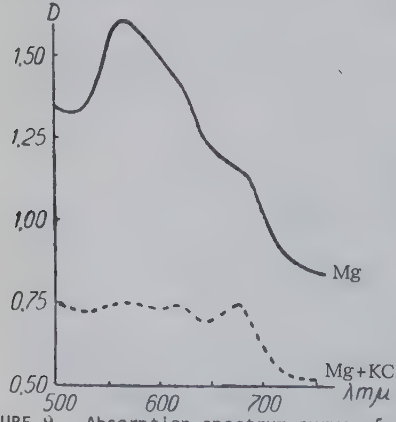


FIGURE 9. Absorption spectrum curves for suspension of loess-like clay

those of montmorillonite clays.

The picture taken with an electron microscope (fig. 10) shows semitransparent iso-

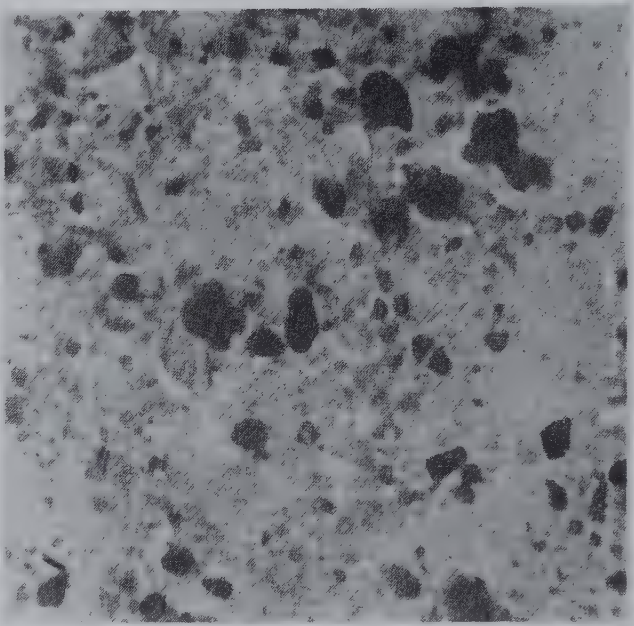


FIGURE 10. Photograph of loess-like clay taken under electronic microscope (12,000x)

metric particles with diffuse contours, or small lumps, resembling montmorillonite. Elongated semitransparent mica scales are present to a lesser extent.

Opaque or translucent particles of irregular shape with sharp contours — quartz and black point impurities, probably pyrite — are also present.

The heat curve for the fraction less than 0.001 mm is very close to the one for montmorillonite. The dehydration curve shows that the mineral looses interstitial water below 250°C, and constitutional water below 600°C.

The measurement of the swelling has shown that the process of swelling in loess-like clay is completed in one hour, and can be expressed as the volume 0.1 g/g (10 percent).

The chemical composition of loess-like clay is given in Table 5. (Analyst B. M. Turkevich).

CONCLUSIONS

The investigation of the clays determined that the clays of all three units are not monomineralic. Each clay had particular features which made it possible to speak of a predominance of hydromica or montmorillonite as the chief rock-forming minerals. For example,

TABLE 5. Chemical analysis of loess-like clay recalculated for montmorillonite (fraction<0.001 mm)

Oxides	Weight in percent	Number of molecules	Number of oxygen atoms	Number of oxygen atoms computed for 12	Atomic number of cations	Number of cation atoms
SiO_2	54.41	906	1812	8.2	906	4.1
TiO_2	0.87	011	022	0.1	011	0.05
Al_2O_3	15.78	155	465	2.1	310	1.4
Fe_2O_3	3.42	021—002—019	057	0.23	038	0.17
FeO	0.06	001—001				
MnO	not determined					
CaO	0.50	009	009	0.04	009	0.04
MgO	1.54	037	037	0.16	037	0.16
K_2O	1.99	021	021	0.1	042	0.2
Na_2O	0.93	015	015	0.07	030	0.14
P_2O_5	0.03	—	—	—	—	—
H_2O—	13.32	739	739	221 1.0		2.0
ignition loss	7.39	408	408			
S	0.20	006				
	100.44		$-\frac{3585}{925}$	12.00		
		Common denominator: 2660:12=221.				

To determine absorption water we use the formula:

$$X=\frac{2mC-\kappa A}{2m-\kappa}-\frac{2\cdot12\cdot1147-2\cdot3585}{2\cdot12-2}=925$$

$$C-X-3585-925=2660;\qquad X=925:221=4.2$$

Hence, the crystal chemical formula is:

$$(K_{0.2}Na_{0.14}Ca_{0.04}Mg_{0.17}Al_{1.4}\dddot{Fe}_{0.17}Ti_{0.05})_{2.17}(OH)_2[Si_4O_{10}]\cdot4.2H_2O$$

$$SiO_2:R_2O_3=5.2$$

$$pH=8.20$$

hydromica predominates in the blue-gray clay, while reddish-brown and loess-like clays are mainly montmorillonitic. These conclusions are completely confirmed by computations of the parameters of the unit cells, which have been made from our data by E. N. Yeliseyev (tables 6 and 7).

In conclusion the author expresses his appreciation to Professor D. P. Bobrovnik and to docent M. P. Gabinet for their valuable advice in connection with the present work.

TABLE 6. Lattice parameters of clays studied compared with hydromica

Lattice in kX	Clays			Hydro-muscovite according to Strunz	Muscovite according to Mikheyer	Hydromica according to Vikulova and others
	Light bluish-gray clay	Reddish-brown clay	Loess-like clay			
a_0	5.208	5.203	5.214	5.2	5.193	5.19
b_0	9.012	9.012	9.00	9.0	8.988	8.96
c_0	19.91 ± 0.20	19.94 ± 0.21	19.70 ± 0.22	20.0	20.003	20.6 (10.3x2)
β	95°59′ ± 40′	95°21′ ± 50	95°16′	96°	95°30′	101°

TABLE 7. Lattice parameters of clays studied compared with montmorillonite

Lattice parameters	Clays			Montmorillonite	
	Light bluish-gray clay	Reddish-brown clay	Loess-like clay	According to Strunz	According to Vikulova and others
a_0	5.17	5.16	5.16	5.17	5.18
b_0	9.05 ± 0.02	9.07	8.93	8.94	8.96
c_0	15.29	15.23	15.20	15.2	10
β	97°51′	97°29′	approx 97°	90°	approx 100°

REFERENCES

1. Mikheyev, V. I., 1957, Rentgenometricheskiy opredelitel mineralov [X-RAY DETERMINATION OF MINERALS]: Gosgeolizdat.

2. Sobolev, V. S., 1959, Vvedeniye v mineralogiyu silikatov [INTRODUCTION TO MINERALOGY OF SILICATES]: Izd. Lvov University.

3. Vikulova, M.F., 1957, Metodicheskoye rukovodstvo po petrografo-mineralogi cheskomu izucheniyu glin [METHODOLOGICAL HANDBOOK ON PETROLOGIC AND MINERALOGIC DETERMINATION]: Gostekhizdat.

METASOMATIC ZONALITY AND GENESIS OF SAPPHIRINE-BEARING ROCKS IN THE BUG REGION[1]

By

E.B. Nalivkina

• translated by Royer and Roger, Inc. •

ABSTRACT

Precambrian sapphirine-bearing rocks were discovered in the core of a borehole on the River Bug in the zone of the metasomatic changes of the pyroxene body. Their origin is a particular case of regional granitization and takes place in connection with the formation of charnockite. The area of modified pyroxenite, 1.7 m thick in the core, has a symmetrical zonal structure and is subdivided into six subzones (in the direction to the center). I. Pyroxenite, serpentinized, carbonatized pyroxenite (initial rocks); II. Diopside-phlogopite-anorthite; III. Corundum-anorthite phlogopite; IV. Sapphirine-corundum-microcline-biotite; V. Corundum-sillimanite-sapphirine-microcline; VI. Sillimanite-sapphirine-corundum-prismatine-microcline. The minerals are not unstable together, some are replaced by others with a general tendency to forming a microcline rock. --Author's English Summary.

***

Rare, singular sapphirine-bearing rocks with such infrequently occurring alumina-bearing minerals as sapphirine and prismatine were found in a zone of charnockite formations along the River Bug, in the area of the former Kapitanovka. These rocks were discovered in cores of a hole bored in 1954 by the Bug Expedition of the Ukrainian Geological Administration; they represent a part of a pyroxenite altered by metasomatism. Their origin is closely associated with the formation of the charnockites. This paper will deal with the alteration of the pyroxenite into sapphirine-bearing rocks later replaced by zones of metasomatism, and the description of these minerals.

The earliest rock formations along the River Bug are Precambrian gneisses. The most widespread among these are pyroxene-plagioclase gneiss, while biotite-plagioclase, amphibiolite-plagioclase, garnet-sillimanite-cordierite-quartz, garnet-biotite, graphitic gneisses and marble are less frequently found. Large gneiss formations are encountered in the basin of the Yuzhnyy Bug River, in the area of the left tributaries of the Dniester — the rivers Murafa, Murashka, Lozovaya, etc. They occur in faults striking predominantly northwest and dipping at an angle close to 90°. The above rocks have a schistose structure, with interlayers of irregular thickness and varying composition. According to various researchers they represent a metamorphosed sedimentary-volcanogenic stratum. The gneiss strata include small comformable bodies of basic and ultrabasic rocks.

The gneisses and basic and ultrabasic intrusives have been altered by subsequent granitization, that has formed huge fields of charnockite and pink aplite-pegmatoid granites. The formation of the sapphirine-bearing rocks is a local and particular case of this process.

Alteration of pyroxenite with the formation of sapphirine-bearing rocks was discovered at the border of an ultrabasic intrusion. Henceforth this area will be designated as a "zone". The zone of altered pyroxenite exposed by the drill hole has a small thickness, of only 1.7 m, in the core. Moreover related formations were encountered in the drill cores of boreholes which exposed other ultrabasic intrusions.

The zone described has a complex symmetrically zonal structure (fig. 1). The axial part is likely to have served as a feeding channel for the solutions and consists of sillimanite-sapphirine-corundum-prismatine-microcline rocks — the end product of the alteration of pyroxenite.

The area is divided into the following six subzones from the periphery toward the center:

I. Pyroxenite, serpentinized and carbonatized pyroxenite (initial rocks).

II. Diopside-phlogopite-anorthite rocks; 25 cm thick.

III. Corundum-anorthite-phlogopite rocks; 1.5 cm thick.

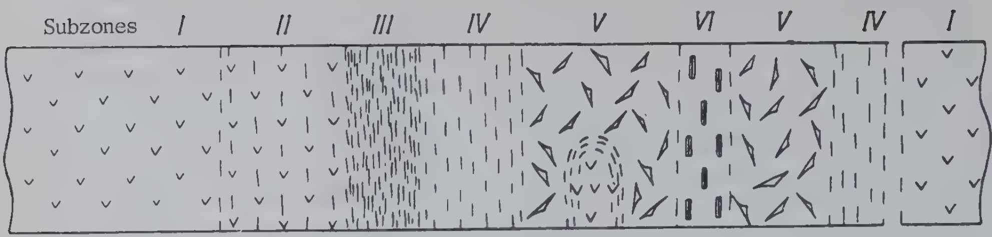
IV. Sapphirine-corundum-microcline-biotite rocks; 20 cm thick.

V. Corundum-sillimanite-sapphirine-microcline rocks; 30 cm thick.

VI. Sillimanite-sapphirine-corundum-

---

[1]Translated from Metasomaticheskaya zonalnost i genezis sapfirinsoderzhashchikh porod pobuzhya: Mineralogichesky Sbornik Lvovskogo Geologicheskogo obshchestva, no. 13, 1959, p. 158-177. Reviewed for technical content by George Faust.



Scale: approximately 1:9

- pyroxenite, serpentinized and carbonatized pyroxenite and serpentinite;
- diopside-phlogopite-anorthite rocks;
- corundum-anorthite-phlogopite rocks;
- serpentinite-corundum-microcline-biotite rocks;
- corundum-sillimanite-sapphirine-microcline rocks;
- sillimanite-sapphirine-corundum-prismatine-microcline rocks.

FIGURE 1. Zone of metasomatic alteration of pyroxenite

prismatine-microcline rocks; 10 cm thick (central part of the area).

As previously noted, the subzones are symmetrically located with respect to the axial part; however, the rocks of subzones II and III are lacking on one side, possibly because of the incompleteness of the drill core. They are also absent in the transition from the unaltered zone (subzone I) directly to subzone IV. Transitions between subzone I, II and III are gradual. The boundary between subzones III and IV is sharply outlined, while between subzones IV, V and VI the transitions were again found to be gradual. In the case of transition from subzone I directly to subzone IV (this refers to the relict zone), the boundary is once again not sharply outlined.

The Outermost Subzone I

This subzone is composed of the original ultrabasic rocks, has a heterogeneous structure which changes irregularly over small distances, and occasionally even within a single thin section, from pyroxenite to serpentinite or carbonatized and serpentinized pyroxenite. The altered pyroxenite contains diopside, some olivine, spinel, serpentine, calcite and small quantities of phlogopite. The serpentinite is composed of antigorite, with small amounts of spinel.

The percentages of minerals contained in the altered pyroxenite vary considerably. The structure of the rocks of this subzone is as heterogeneous as their composition: in areas consisting almost entirely of diopside, the structure is panidiomorphic; in areas where calcite prevails, it is heteroblastic; in the stongly serpentinized areas, the rocks have a lath or lattice structure.

The rocks of subzone I (serpentinite) were also found in the form of relicts in subzone V where they are surrounded by the rock of subzone IV.

Subzone II

The diopside-phlogopite-anorthite rocks are uniformly granular (grain size about 0.5 mm). Their color is brown. They are composed of anorthite (40 percent), phlogopite (35 percent) and diopside (25 percent). Their structure is lepidogranoblastic.

Subzone III

The corundum-anorthite-phlogopite rocks are considerably richer in phlogopite than the rocks of the preceding subzone. They contain 60 percent phlogopite. The rest consists of anorthite, deep-colored pink corundum and individual grains of spinel. The corundum is distributed in irregular lumps, so that there are areas where it is completely absent.

The rocks have a granolepidoblastic texture; in the corundum-enriched areas it is porphyroblastic, the groundmass having a granolepidoblastic structure. Closer to the center of the zone, the corundum-anorthite-phlogopite rock is replaced by sapphirine-corundum-microcline-biotitic rock.

Subzone IV

The sapphirine-corundum-microcline-biotite rocks are composed of biotite (37 percent), microcline (45 percent), corundum (16 percent) and sapphirine. Small amounts of spinel and thin needles of sillimanite are also encountered. The rocks have a grayish-brown color, massive texture, granolepidoblastic structure with porphyroblastic areas. The porphyroblasts consist of corundum 2.5 cm in size, microcline up to 1 cm in size, and sapphirine up to 2.5 cm in size. The grain size of the groundmass is from 1.0 to 1.5 mm.

Subzone V

The corundum-sillimanite-sapphirine-micro-

cline rocks contain up to 77 percent microcline, 14 percent sapphirine, 4 percent sillimanite, 3 percent biotite and some corudum and spinel. The color of these rocks is gray bluish-gray. Their texture is massive, their structure is porphyroblastic with a granoblastic groundmass. The porphyroblasts are composed of sapphirine (2.5 mm in size), microcline (0.5 to 1 cm in size) and occasionally corundum (up to 1 cm in size). The groundmass mainly consists of microcline with grains reaching 1 to 1.5 mm in size.

Subzone VI

The central part of this zone is composed of sillimanite-sapphirine-corundum-prismatine-microcline rocks. It differs from the rocks of the preceding zone in that the spinel disappears completely, and it contains large prismatine porphyroblasts around which the sapphirine and sillimanite disappear as well.

MINERALS OF THE METASOMATIC ZONE

The mineral composition of the rocks varies from one subzone to the other. Some minerals disappear gradually and are replaced by others; other minerals are sharply and discontinuously replaced by others, while some others are found in all of the subzones, the only change consisting of a slight variation in their composition, as will be seen in the description of the minerals below.

Diopside is the rock-forming mineral of subzone I. It occurs here in comparatively idiomorphic units, in sizes up to 1.5 mm. It is colorless; $2V=+57^{o}$ and $C\wedge\gamma=40^{o}$ to 41^{o}. In subzone II diopside is found in lesser amounts, in the form of xenomorphic grains with corroded contours. Here we only succeeded in computing $2V=+56^{o}$ (along two axes).

Olivine is found in very small amounts in the rocks of subzone I, where it is usually replaced by serpentine. We determined $2V=-87^{o}$ (along the axes) for this mineral, which corresponds to the magnesium variety.

Serpentine was discovered only in subzone I. It replaces the olivine, which is preserved only in individual cases, and diopside; in addition, it is also found in the entirely carbonatized and serpentinized pyroxenite along small cracks in the spinel grains. Serpentine is represented by fine-lamellar antigorite closely intergrown with very fine scales of a micaceous mineral, probably phlogopite. For antigorite $\gamma=1.576$; the elongation is positive. The heating curve of serpentine (fig. 2) discloses an endothermic effect at 620^{o} and an exothermic peak at 730^{o} to 740^{o}. I. I. Ginzburg and I. A. Rukavishnikova indicate in their paper (1951, p. 23) that at these

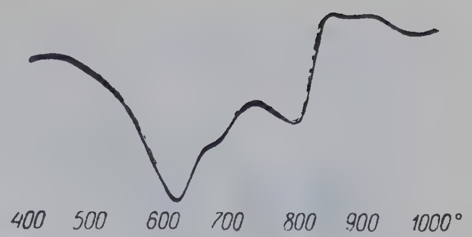


FIGURE 2. Heating curve of antigorite with admixtures of micaceous mineral

temperatures, thermal effects are characteristic of serpentines. On the curve shown here, the exothermic peak is flatter than usual in the case of serpentines. This phenomenon, as well as a series of endo- and exothermic effects at temperatures above 740^{o}, according to V. P. Ivanova, is likely to be connected with the micaceous mineral present in the rocks.

Carbonate has also been discovered only in subzone I. Being a secondary mineral, it is thermally identified as calcite by its intense endothermic effect at 970^{o}.

Green spinel is found in subzones I, III, IV and V. Judging by its refraction (1.754), this mineral is likely to be pleonaste. Small grains of green spinel with rounded outlines are found in subzones I and III. In the areas where serpentine is replaced by microcline, a thin rim of sapphirine appears around the spinel grains (fig. 3); this rim is much better formed in sub-

FIGURE 3. Replacement of serpentine (1) by microcline (2). Some spinel (3) with sapphirine rims (4) around it. Nicols +; magnification 8x20.

zones IV and V, where the spinel is preserved here and there in the form of "armored relicts" (fig. 4). In subzone VI the spinel is entirely replaced by sapphirine and disappears.

Small amounts of phlogopite appear in the form of fine scales in subzone I. Here it replaces diopside, and probably serpentine, with

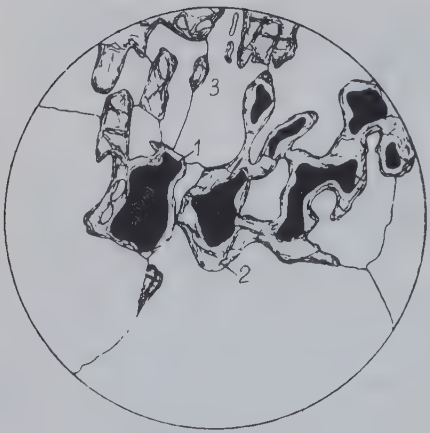


FIGURE 4. Replacement of spinel (1) by sapphirine (2), and of sapphirine by microcline (3). Sapphirine represents disconnected portions of one grain. Nicols +; magnification 12.5x8.

which it forms very fine intergrowths. The pleochroism of the phlogopite in subzone I along γ-β is light greenish-brown. Along ω it is colorless. The index of refraction γ-β=1.606. In subzone II phlogopite is found in fairly large amounts. Its scales are larger than those in subzone I, the pleochroism is identical to that of the phlogopite of subzone I, and the index of refraction γ-β=1.607. Subzone III contains even more phlogopite than the other two subzones. Here it even replaces anorthite, penetrating in denticular aggregates along the cleavages and between the grains of anorthite (fig. 5). The data from the spectrum

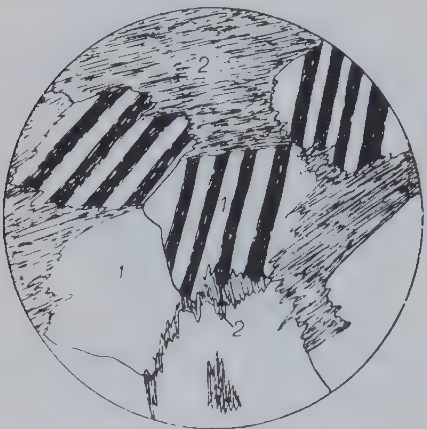


FIGURE 5. Replacement of anorthite (1) by phlogopite (2). Nicols +; magnification 12.5x8.

analysis of the phlogopite of this subzone are given in Table 6. It is noteworthy that the phlogopite of this subzone contains admixtures of Ni, Co and Cr. In the transition to subzone IV, the phlogopite of subzone III is abruptly and discontinuously replaced by biotite. However, in the transition from subzone I to subzone IV, and even V (this refers to the serpentine relict inside subzone V), the phlogopite changes gradually, its composition becoming more ferruginous, and finally turns into biotite. This is seen by comparing the indices of refraction which systematically increase from γ-β=1.606 through to γ-β=1.617; γ-β= from 1.624 to 1.630.

Biotite is found in subzones IV, V and VI. Toward the latter its quantity sharply decreases from 37 to 3 percent, owing to replacement by microcline. The biotite is brown; its pleochroism along γ-β is reddish-brown; along α it is light brown. γ-β=1.630. The interrelation of phlogopite with biotite in the various subzones was mentioned earlier.

Anorthite is found only in subzones II and III. In subzone II its grains are comparatively idiomorphic. Here it replaces diopside. In subzone III, as a rule, anorthite compounds are xenomorphic and are destroyed and replaced by phlogopite (cf. fig. 5). Polysynthetic twinning is characteristic of anorthite. Measurement of the twin yielded: $B\wedge\gamma=53^{\circ}$; $B\wedge\beta=58^{\circ}$; $B\wedge\alpha=53^{\circ}$; the Carlsbad twinning law is N95. In subzones IV, V and VI anorthite was not discovered. Its interrelation with the minerals of subsequent subzones were also not observed.

Corundum appears in subzone III and is found in subzones IV, V and VI. It forms aggregates of tabular crystals with well developed pinacoids, with laminae up to 1 cm in size (subzone III); in this subzone the corundum is likely to replace anorthite rich in alumina. Moreover it is found in microcline-corroded porphyroblasts 0.5 cm in size (subzone IV), as well as in individual microcline-corroded porphyroblasts elongated in the direction of the third crystallographic axis up to 1 cm (subzones V, VI).

It is interesting to note that the corundum changes color from a rich pink (subzone III) to pale pink (subzone IV) and light gray (subzones V and VI). Its refractive indices are also not constant: corundum of subzone III (rich pink) has ω=1.765 and ϵ=1.760; corundum of subzone V (light gray) has ω=1.757 and ϵ=1.749; i.e., the values are slightly smaller. Comparison of the spectrum analyses of the rich pink and light gray mineral varieties (see table 6) shows that the first is comparatively rich in chromium. In addition, the gray corundum has been diagnosed by X-rays. Table 1 shows the results of the X-ray analysis[2] juxtaposed with those of standard tests (Kovalev, 1937).

[2]The X-ray analyses cited in this paper were made at the VSEGEI laboratory.

TABLE 1. X-ray analysis of gray corundum
Conditions: Fe - anticathode, voltage on tube 35kV, current 12 mA. Exposure, 4 hrs. 30 min. Camera diameter 57.3 mm, diameter of a specimen column, 0.5 mm. Corrections by special photograph of mixture with NaCl.

Gray corundum of the Bug region			Gray corundum (G. A. Kovaleva, 1937), standard sample			hkl
I	$\frac{d\alpha}{n}$	$\frac{d\beta}{n}$	I	$\frac{d\alpha}{n}$	$\frac{d\beta}{n}$	
2	(3.79)	3.42	3	(3.81)	3.46	$10\bar{1}2$
7	3.44		7	3.46		$10\bar{1}2$
1	3.30		1	3.35		—
2	(2.77)	2.52	4	(2.81)	2.54	$10\bar{1}4$
			1	(2.61)	2.37	$11\bar{2}0$
8	2.53		9	2.54		$10\bar{1}4$
3	2.36		5	2.37		$11\bar{2}0$
1	2.32					—
2	(2.28)	2.07	4	(2.29)	2.08	$11\bar{2}3$
10	2.07		9	2.08		$11\bar{2}3$
1	(1.910)	1.730	3	(1.917)	1.740	$20\bar{2}4$
3	(1.755)	1.592	5	(1.759)	1.596	$11\bar{2}6$
7	1.729		7	1.735		$20\bar{2}4$
10	1.592		1p	1.667		—
			10	1.596		$11\bar{2}6$
2	(1.540)	1.397	4	(1.546)	1.402	$21\bar{3}4$
1	1.512		5	(1.510)	1.370	—
2	(1.507)	1.367				$30\bar{3}0$
6	1.397		8	1.401		$21\bar{3}4$
7	1.368		9	1.371		$30\bar{3}0$
						—
						$20\bar{2}7$
			1p	1.332		
1	1.305		2	(1.309)	1.187	$22\bar{4}0$
			1	1.272		—
			1	(1.262)	1.145	$22\bar{4}3$
7ш	1.235		6	1.237		101.10
			4	1.232		
1	1.207	1.095	2	(1.210)	1.096	202.10
3	1.183		6	1.186		$22\bar{4}0$
1	1.155		1	1.155		
3	1.143		6	(1.144)	1.038	$22\bar{4}3$
3	1.119		6	1.123		$21\bar{3}8$
5	1.095		7	1.096		202.10

Note: The lines on the Debye powder patterns: d = 3.30; 2.32; 1.272; 1.155; are those of the admixture.

A comparison of parameters of the unit cells of the gray corundum of the Bug region with those of the standard corundum sample is given in Table 2.

TABLE 2. Parameters of corundum unit cell

Citation of paper / Parameters	Gray corundum of Bug region	Gray corundum of G. A. Kovalev, 1937), Standard sample
a	4.74 ± 0.01 kX	4.75 ± 0.01 kX
c	12.89 ± 0.02 kX	12.91 ± 0.02 kX

Sapphirine was found in subzones IV, V and VI. Negligible amounts of it were also discovered in subzone I, in areas where serpentine is replaced by microcline. There it forms rims around spinel grains (fig. 3). These rims become wider in subzones IV and V (fig. 4). In addition, sapphirine is found in individual grains (subzones IV, V and VI) of tabular or columnar structure elongated along the γ-axis (fig. 6). The sapphirine formations are stongly corroded by microcline (figs. 4, 6).

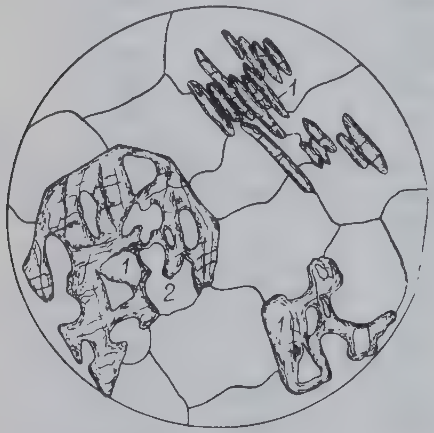


FIGURE 6. Character of sapphirine grains (1) and their corrosion by microcline (2). Without analyzer. Magnification 12.5x8.

Sapphirine has no cleavage. Its color is blue with sharp pleochroism: bright blue along γ, pale blue along β almost colorless along α. 2V=-69-70° (along two axes); refraction: γ= 1.722; α=1.717; birefringence: γ-α=0.005 (computed). For a comparison of the investigated sapphirine with that of other areas, Table 3 gives their optical characteristics.

The parameters of the unit cell of sapphirine of the Bug region as compared to those of the Greenland sapphirine (verbal communication of VSEGEI collaborator A. I. Kamkov) are given in Table 4.

TABLE 4. Parameters of sapphirine unit cell

Parameters \ Mineral	Sapphirine of Bug region	Greenland sapphirine
a	9.78kX	9.78kX
b	14.37kX	14.37kX
c	9.68kX	10.00kX
β	110°12'	115°15'

The data of X-ray analysis of the Bug region sapphirine are given in Table 5. As can be seen, they are very close.

Spectrum analysis gives some idea of the chemical composition of the sapphirine (see table 6). Upon examination, one's attention is attracted by the admixture of Ni, Co, Cr; i.e., the typical elements of ultrabasic rocks.

Sillimanite was found in subzones IV, V and VI. In subzone VI it appears in the form of very thin needles on the corundum. In subzones V and VI the mineral forms columnar grains which apparently replace sapphirine. Sillimanite is in turn replaced by microcline. 2V= +27° (along two axes).

Prismatine was formed in the axial part of the zone (subzone VI) in a small interspace. It consists of large columnar porphyroblasts several centimeters long and up to 1 cm wide. The mineral is bottle-green, almost colorless

TABLE 3. Optic properties of sapphirine

Characteristics	Bug region	Western Australia Dangin (Prider, 1945)	Western Greenland (Ramberg, 1948)	North America, Cortlandt (Friedman, 1952)
Cleavage	Absent	Absent	-	‖(010) not clearly defined
Color	Blue	Light blue	Light blue	Blue
Pleochroism:				
along γ	Bright blue	Deep blue	-	Blue
along β	Light blue	Blue	-	Light blue
along α	Colorless	Pale, yellowish-green	-	Yellowish-green
Absorption system	$\gamma > \beta > \alpha$	$\gamma > \beta > \alpha$	-	$\gamma > \beta > \alpha$
Dispersion of elements and indicatrix	Gray, anomalous interference color	Dispersion of optical axes strong, r<v	-	Gray anomalous interference color
2V	-69 - 70°	Approx. 50°	-	-
γ	1.722	-	1.7195 ± 0.001	-
β	-	1.720 ± 0.02	-	-
α	1.717	-	1.714 ± 0.001	-
$\gamma - \alpha$	0.005 (comput.)	-	0.006	-

TABLE 5. Data of the Debye crystallogram of sapphirine
Photograph conditions: Fe - anticathode, camera diameter 85.95 mm, diameter of sample column 0.5 mm. Current, 15 mA; voltage at tube, 35 kV. Exposure, 10 hours (without filter). Corrections effected by a special photograph with NaCl.

Number	I	$\frac{d\alpha}{n}$	$\frac{d\beta}{n}$	hkl	Number	I	$\frac{d\alpha}{n}$	$\frac{d\beta}{n}$	hkl
1	5p	(3.29)	2.99		38	2p	1.370		
2	1	3.24			39	2	1.356		
3	2	3.12	2.83		40	2	1.347		
4	6	2.99		310	41	1	1.335		
5	1	2.89			42	4	1,307		
6	6	2.84		240	43	1	1,295		
7	3	2.77			44	1	1,284		
8	4	(2.70)	2.445		45	1	1.277		
9	1	2,646			46	4p	1.270		
10	4	2.575			47	4	1.242		
11	10	2.444		2.0$\bar{4}$	48	2	1.238		
12	2	2,389			49	2	1.215		
13	5	2.346			50	2	1.208		
14	4p	(2.221)	2.013		51	3	1.186		
15	2	2.157			52	3	1.173		
16	4	2.127		260	53	2	1.165		
17	1	2.063			54	3	1.149		
18	10	2,016		40$\bar{4}$·252	55	1	1.140		
19	1	1.952			56	1	1.134		
20	1	1,916			57	2p	1.117		
21	4	1,897			58	1	1.111		
22	1	1,856			59	2	1.107		
23	2	1,825			60	1	1.092		
24	2	1.799			61	1	1.085		
25	2	1,760			62	3p	1.065		
26	3p	1,704			63	2	1.057		
27	2p	1,629			64	1	1.054		
28	4	(1,588)	1.439		65	1	1.050		
29	3	(1,565)	1.418		66	2	1.047		
30	4	1,552			67	2	1.044		
31	4	1.540			68	2	1,034		
32	2	1.528		600	69	2	1.032		
33	3p	1.486			70	1	1.028		
34	10	1.437		0.10.0	71	1	1.022		
35	9	1.420			72	2	1.015		
36	5	1,409		404	73	7	1.013		80$\bar{8}\alpha_1$
37	1	1.380			74	3	1.013		80$\bar{8}\alpha_2$

in this section; pleochroism: pale-green along γ, colorless along α. The longitudinal hachures along the crystal faces, similar to those of tourmaline, are characteristic of prismatine. The prismatic cleavage is perfect. Hardness is 7. The mineral is biaxial. Elongation is negative. The angle of the optical axes $2V = 20^{\circ} \pm 2^{\circ}$ (along two axes). Refractive indices: $\alpha = 1.696$; $\gamma = 1.680$. Birefringerence $\gamma - \alpha = 0.016$ (computed). Like the sapphirine, the prismatine is replaced by microcline, its grains being corroded by microcline and forming typical archipelago structures (fig. 7).

It is worth noting that such alumina-bearing minerals as sapphirine, sillimanite and biotite are almost completely absent in the immediate vicinity of the prismatine porphyroblasts. Their constituent elements are likely to have been used in the formation of the prismatine.

In the macroscopic specimen the prismatine resembles both tourmaline and pyroxene; in thin section it resembles andalusite.

TABLE 6. Spectrum analyses of minerals*

Elments \ Minerals	Phlogopite	Deep pink corundum	Light gray corundum	Sapphirine	Prismatine
Si	⩾10	0.1–1.0	3–10	⩾10	⩾10
Al	⩾10	>10	⩾10	⩾10	⩾10
Mg	>10	0.01–0.1	0.1–0.3	⩾10	⩾10
Fe	3–10	0.1–1.0	0.1–0.3	1–3	3–10
Mn	0.01–0.03	0.01–0.1	0.001–0.003	0.01–0.03	0.01–0.03
Ni	*0.1–0.3*	—	*0.001–0.003*	*0.01–0.03*	*0.03–0.1*
Co	*0.01–0.03*	—	—	*0.001–0.003*	*0.003–0.01*
Ti	0.1–0.3	0.01–0.1	—	—	0.001–0.01
V	0.01–0.03	—	0.001–0.003	0.003–0.01	0.01–0.03
Cr	*0.03–0.1*	*1.0–10*	*~0.01*	*~0.01*	*0.03–0.1*
Cu	—	<0.001	<<0.001	<0.001	~0.001
Ga	—	~0.003	0.003–0.01	0.003–0.01	~0,003
Sr	—	~0.03	—	—	—
Ba	~0.03	—	—	—	—
Na	0.1–0.3	—	—	~0,1	~0.1
Li	—	—	—	—	0.01–0.03

*The spectrum analyses were made in the VSEGEI Laboratory. The analysis of light gray corundum, phlogopite and sapphirine was carried out by Ye. Ya. Smirnova, that of pink corundum by O.G. Kvyatkovskaya; analysis of prismatine is based on data by N.A. Kuryleva.

FIGURE 7. Shape of prismatine grains (1) and replacement of microcline (2). Without analyzer. Magnification 12x8.

To characterize the chemical composition of the prismatine, Table 6 gives the spectrum analysis of the mineral. Here, as in the other minerals described earlier, the admixture of Ni, Co and Cr is worth noting.

Prismatine is very rarely encountered, and is usually classified in the group of magnesia aluminoborosilicates (Winchell and Winchell, 1953). It represents a variety of kornerupine, from which it differs by the presence of the (NaH) group, which replaces Mg.

Prismatine first discovered in the Bug region by N. A. Kuryleva (verbal communication). Our data confirm her findings.

Microcline with a distinct lattice is a typical mineral of subzones IV, V and VI, but was already found in subzone I. In the serpentinite (subzone I, relict area in subzone V) there appear small microcline grains, 0.1 mm in size, with wedge-shaped teeth in the contours. In addition, relatively large porphyroblasts with denticular contours (see fig. 3) up to 1.5 mm in size are also formed here.

When microcline replaces the antigorite groundmass, a fine laminar micaceous mineral first develops along the antigorite and indistinguishable from the latter. Moreover, as we noted above, a sapphirine rim is formed around the spinel contained in the rock. In subzones IV, V and VI, the microcline is usually found in

ound, isometric, large or small grains which orrode the sapphirine, sillimanite and prisnatine (see figs. 4, 6, 7, 9). It should be noted iat pseudomorphic microcline forms after silmanite, retaining the outer shape of the silmanite grains, and that it replaces biotite.

ALTERATION OF THE MINERALS AND CHEMICAL COMPOSITION OF THE ROCKS

On the basis of the preceding statements it s possible to establish two successively alterating stages in the alteration of the pyroxenite. erpentinization and carbonatization belong to he first stage; they are the ordinary phenomena ssociated with postmagmatic activity during he formation of ultrabasic intrusions. The econd stage comprises all those alterations which have led to the formation of the metasomatic zonality described above: anorthitization, hlogopitization, formation of corundum, saphirine, sillimanite, prismatine and microcline. These phenomena are due to granitization, which s widespread in this region.

Let us analyze the alterations of the minerals occurring during the second stage. As seen from factual data, most of the minerals of ach subzone are unstable: some are replaced y others with a tendency toward replacement f all of them by microcline, i.e., toward the ormation of a monomineralic rock. Minerals with a chemical affinity and occurring simultaneously in several subzones are interconnected y a successive replacement or by some variaion in their chemical composition, as seen on he diagram in Figure 8.

As an example, let us take the behavior of minerals containing large amounts of magnesium and iron. The antigorite and diopside of subzone I are replaced by phlogopite, while the diopside is replaced by anorthite as well. Phlogopite occasionally varies its composition and is altered to biotite, by which it is sometimes replaced quite abruptly. In the further course of the process the biotite is replaced by microcline; i.e., there is first a removal of calcium, then of magnesium, and subsequently of iron, as well as an addition of potassium, silica and, apparently, alumina.

In magnesium- and iron-bearing minerals containing large amounts of alumina, the alterations start with spinel. This is replaced by sapphirine; sapphirine is probably replaced by sillimanite; sapphirine is apparently replaced by prismatine; sillimanite, sapphirine and prismatine are replaced by microcline.

Comparison of the formulas below for the successively replaced minerals shows that during the process described above, there is a loss of iron and magnesium, and an addition of silica, potassium and boron.

$(MgFe)OAl_2O_3$ - spinel

$(MgFe)OAl_2O_3 \cdot \frac{1}{2}SiO_2$ - sapphirine

$MgO(AlB)_2O_3SiO_2$ - prismatine

$Al_2O_3SiO_2$ - sillimanite

$K_2OAl_2O_3 \cdot 6SiO_2$ - microcline

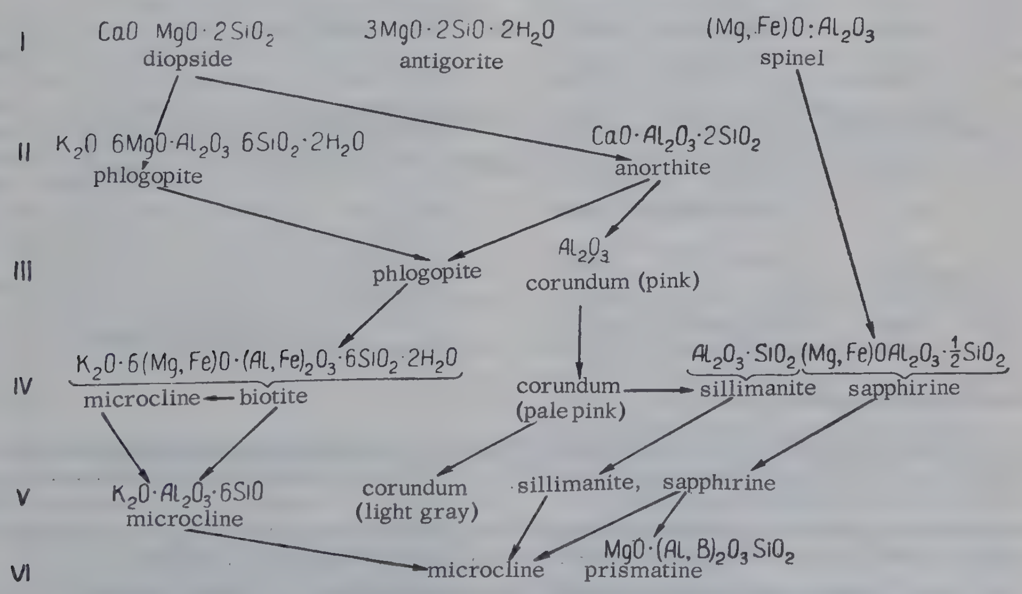


FIGURE 8. Mineral replacement and alteration diagram. The Roman numerals indicate the subzones.

In the case of alumina-bearing minerals the following alterations have been established: dark pink corundum is likely to replace anorthite. In the subsequent zones the color of corundum becomes lighter and changes to light gray, apparently because of its loss of iron, magnesium and chromium. Corundum is replaced by sillimanite, and the latter by microcline. Thus here too, we notice first the loss of calcium, then of iron, magnesium and chromium, and the addition of silica and potassium.

The observed alterations are evidence that calcium-, iron- and magnesium-bearing minerals are replaced by potassium-, silica- and alumina-bearing minerals; i.e., that the second stage of alteration is characterized by an addition of K, Si, B and probably Al, connected with granitization.

By observing the replacement of minerals, the qualitative aspect of the process becomes evident.:

Let us now follow the quantitative alterations by comparing the chemical composition of the various zones. To this end we analyzed three types of rocks. The results of the analyses are shown in Table 7, which, in addition to percent by weight, also shows the molecular numbers (1a, 2a, 3a) and percentages (1b, 2b, 3b) [calculated to 100 percent?-G. F.].

TABLE 7. Chemical composition of rocks in subzones I, II and IV

Oxides	1	2	3	1a	2a	3a	1b	2b	3b
SiO_2	18,97	38.62	52.00	0316	0643	0866	15.65	38.53	59.52
TiO_2	—	0.67	0.15	—	0009	0002	—	0.54	0.14
Al_2O_3	6.85	24.38	29.30	0067	0239	0278	3.32	14.32	19.11
Fe_2O_3	2.78	1.55	0.92	0017	0009	0006	0.84	0.54	0.41
FeO	4.15	4.85	1.38	0058	0067	0019	2.87	4.02	1.30
MnO	0.44	0.21	0.03	0006	0003	—	0.30	0.18	—
MgO	15.75	13.17	5.22	0390	0326	0129	19.33	19.53	8.87
CaO	24.36	5.14	0.41	0434	0092	0007	21.51	5.51	0.48
Na_2O	0.12	0.12	0.15	0002	0002	0003	0.10	0.12	0.21
K_2O	0.64	7.42	9.37	0007	0079	0100	0.35	4.73	6.87
H_2O	1.06	0.38	0.12	—	—	—		—	
Ignition loss	4.70	3.61	0.68	0261	0200	0038	12.93	11.98	2.61
CO_2	20.26	—	0.30	0460	—	0007	22.79		0.48
NiO	0.05	0035*	traces	—	—	—			
CO [CoO?]	traces	0004*	0.003	—	—	—			
Total	100.13	100.15	100.033				100.00	100.00	100.00

*Decimal point not specified -G. F.

1. Carbonatized, serpentinized pyroxenite from subzone I. Mineral composition: diopside, 41 percent; serpentine, 26 percent; calcite, 23 percent; spinel, 9 percent; small quantities of olivine and phlogopite. Analysis by M.T. Selyutina.
2. Anorthite-phlogopite-bearing rocks from subzone III. Mineral composition: phlogopite, about 60 percent; anorthite, about 38 percent; some corundum. Analysis by L. G. Potepalova.
3. Corundum-sillimanite-sapphirine-microcline rocks from subzone V. Mineral composition: microcline, 77 percent; sapphirine, 14 percent; sillimanite, 4 percent; biotite, 3 percent; some corundum and spinel. Analysis by M. T. Selyutina.

Variation curves (fig. 9) are plotted on the basis of the data from the chemical analyses.

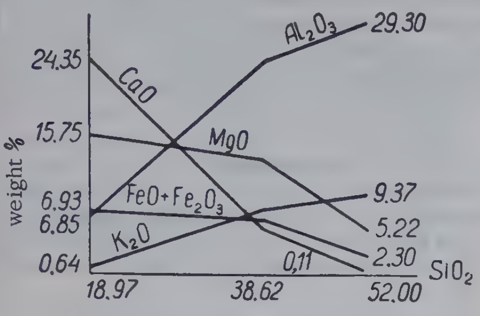


FIGURE 9. Variation curves

The content of silica in percent by weight, for the rocks of subzones I, III and V, is marked on the abscissa, and that of all the remaining oxides in percent by weight is marked on the ordinate. Thus each curve characterizes the quantitative variation in the content of the various oxides in transition from one subzone to another.

Comparison of the chemical analyses (see table 7) and the diagram (fig. 9) show that when altered pyroxenite (subzone I) grades into a corundum-sillimanite-sapphirine-microcline rock the contents of K, Si and Al increase and those of Ca, Mg and Fe decrease. These data correspond to the alteration found to take place in the replacement of the minerals. The admixtures of Ni and Co in the rocks of subzones III and V, and of Ni, Co and Cr in the minerals of subzones III, IV, V and VI are also evidence of the genetic relationship between the metasomatic subzones and the ultrabasic rocks.

D. S. Korzhinsky (1953) explains the formation of the metasomatic zones and the tendency toward a monomineralic rock as follows: in the most highly altered zone the rock composition is in equilibrium with the incoming solution and depends solely on the concentration of components in the solution, and not on the original composition of the altered rock. The composition of the more remote rocks reflects the result of interaction between the rocks and incoming solution. During the transition from unaltered to more altered rocks the number of completely volatile components increases, while that of the inert components decreases. As a result, the number of minerals in the zone is reduced to the point of forming a monomineralic rock.

All this shows that the sapphirine-microcline rocks of the Bug region were formed in the course of metasomatic alteration of a pyroxenite by solutions introducing K, Si, B and probably Al, with the formation of metasomatic zones and of minerals successively replacing each other. The sources of these elements could hardly be the cordierite-quartziferous gneiss rocks surrounding the drill hole, since these are poor in potassium.

CONCEPTIONS OF THE GENESIS OF THE SAPPHIRINE-BEARING ROCKS

The distribution of sapphirine-bearing rocks throughout the world is quite limited, and there are few references to them in the literature. It is known from the papers published on this subject that these rocks are associated with Precambrian formations, including charnockites, in such regions as the Anabar shield, Dangin (Western Australia), Greenland, Southeastern India, etc.

In Greenland the sapphirine-bearing rocks were studied by H. Ramberg (1948). The region consists of Precambrian dioritic and quartz-dioritic gneisses related to the charnockites, and enclosing bodies of metamorphosed basic and ultrabasic rocks. According to the author, these had originally been pyroxenites and other ultrabasic and gabbroic igneous rocks.

It is with these metamorphosed formations that the sapphirine and related minerals (spinel, phlogopite, plagioclase) are associated. As a rule, sapphirine forms rims around the spinel, together with bronzite; in addition, it was occasionally also found without spinel.

According to H. Ramberg, the sapphirine-bearing rocks arose as follows: all the formations mentioned above were subjected to plutonic metamorphism, in the course of which there was extensive metamorphic differentiation, involving the migration of elements and introduction of such components as Si and K into the basic rocks from acidic ones, while Fe, Mg and Ca were added to the latter. The author holds that although sapphirine is stable even within a considerable variation in the chemical composition of the rocks, yet its development is limited to a narrow range of temperatures and pressures between the granulite and amphibolite facies. This explains the fact that sapphirine is a fairly rare mineral. Thus it may serve as a mineralogic thermometer.

The sapphirine-bearing rocks of Western Australia (Dangin region) were investigated by R. T. Prider (1945). This region is composed of Precambrian hypersthene-bearing granite-gneisses (charnockite) enclosing xenoliths of ultrabasic and basic rocks modified into hornblende hypersthenites, garnet-cordierite-hypersthene rocks and vermiculite schists. Sapphirine was found in association with vermiculite rocks. According to Prider, the genesis of the sapphirine-bearing rocks of Western Australia is the following: under the action of a granitic magma introducing K, Al and SiO_2, the spinel-bearing hypersthenites were first altered to mica schists and then to feldspar schists with mica and sapphirine.

T. Walker and W. H. Collins (1907) believe that the sapphirine-bearing rocks of the Vizagapatam District (India) were formed through the assimilation of the enclosing sillimanite schists by the charnockite magma.

The sapphirine-bearing rocks at Cortlandt (North America) are described by G. Friedman (1952). Here there are widespread occurrences of peridotite, pyroxenite, norite and diorite, which have been intruded into quartz-mica schists. Corundum-spinel-titano-magnetite rocks are associated with the norite and its contact with the schists. Where these rocks are intersected by quartz veins, reaction rims of garnet, sillimanite, cordierite and sapphirine form around them. The outer zone of the quartz veins is formed by the sapphirine rims. Friedman believes the sapphirine is a replacement product of spinel, which is formed in the norite under the action of silica introduced into it, as well as in enclosing schists at their contact with norites by the reaction between magnesium and iron, removed from the norites, and the schist minerals.

The sapphirine-bearing rocks of the Anabar shield are known through the paper by B. N. Rozhkov, G. G. Moor, and B. V. Tkachenko (1936). The authors, however, do not examine in detail the problems relating to the genesis of these rocks. Nevertheless, it should be noted that the geology of this region is very similar to that of the Bug region. The Anabar shield is composed of Precambrian gneisses, including pyroxene-plagioclase gneiss, and charnockite enclosing bodies of basic and ultrabasic rocks.

In conclusion it should be noted that the formation of aluminous minerals from basic rocks (norites) was also observed in younger formations, but these are not characterized by either sapphirine or prismatine. For example, V. S. Sobolev (1947) has described zonal formations developed in granite from norite xenoliths of the Korosten complex (Ukrainian crystalline massif) under the action of these granites. The outer zone of these formations is mainly cordierite-spinel, while sillimanite predominates in the interior.

CONCLUSIONS

1. Sapphirine-bearing rocks are found in Precambrian formations in association with charnockite.

2. In the Bug region, the formation of sapphirine-bearing rocks parallels the formation of charnockites and is one of the phenomena of regional granitization.

3. Sillimanite-sapphirine-corundum-prismatine-microcline rocks were formed by metasomatic replacement of altered pyroxenite under the action of solutions introducing K, Si, B and probably Al, and removing Ca, Mg, and Fe, with the formation of a metasomatic zonality and successive replacement and alteration of the minerals, and a tendency toward the formation of a monomineralic microcline rock.

REFERENCES

Friedman, G. M., 1952, SAPPHIRINE OCCURRENCE OF CORTLANDT, NEW YORK: Amer. mineralogist. v. 37, no. 3-4, p. 244-249.

Ginzburg, I. I., and Rukavishnikova, I. A., 1951, Mineraly drevney kory vyvetrivaniya Urala [MINERALS OF THE ANCIENT WEATHERING CRUST OF THE URALS]: Izd. AN SSSR.

Korzhinsky, D. S., 1953, Ocherk metasomaticheskikh protsessov. Osnovnyye problemy v uchenii o magmatogennykh rudnykh mestorozhdeniyakh [OUTLINE OF METASOMATIC PROCESSES. BASIC PROBLEMS IN THE STUDY OF MAGMATOGENIC ORE DEPOSITS]: Izd. AN SSSR.

Kovalev, G. A., 1937, Etalonnyye debayegrammy glavneyshikh okislov, gidrookislov i sul'fidov [DEBYE'S STANDARD POWDER PATTERNS OF THE PRINCIPAL OXIDES, HYDROXIDES AND SULFIDES]: Mater. TsNIGRI. Geokhimiya, no. 2.

Polovinkina, Yu. Ir. and Nalivkina, E. B., 1955, K voprosu o sushchestovovanii Podol'skoy charnokito-noritovoy formatsii [ON THE PROBLEM OF THE PODOLIAN CHARNOCKITE-NORITE FORMATION]: Informats. sb. VSEGEI, no. 1.

Prider, R. T., 1945, SAPPHIRINE FROM DANGIN WESTERN AUSTRALIA: Geol. Mag. v. 82, p. 49-54.

Ramberg, Hans, 1948, ON SAPPHIRINE-BEARING ROCKS IN THE VICINITY OF SUKKERTOPPEN (WEST GREENLAND): p. 5-32. Meddelelser Om Grenland videnskabelige undersogelser; Grnland Bd. 142, Nr. 5, Kbenhavn.

Rozhkov, B. N., Moor, G. G., and Tkachenko, B. V., 1936, Materialy po geologii i petrografii Anabarskogo massiva [MATERIALS ON THE GEOLOGY AND PETROGRAPHY OF THE ANABAR MASSIF]: Tr. Arkticheskogo In-ta, v. 66.

Sobolev, V. S., 1947, Petrologiya vostochnoy chasti slozhnogo Korosten'skogo plutona [PETROLOGY OF THE EASTERN PART OF THE COMPLEX KOROSTEN' PLUTON]: Izd.

L'vov. un-ta.

Sobolev, V. S., 1950, Znacheniye zhelezistosti femicheskikh mineralov i vspomogatel'nyye diagrammy dlya opredeleniya sostava biotitov, rogovykh obmanok i rombicheskikh piroksenov [SIGNIFICANCE OF THE IRON CONTENT OF FEMIC MINERALS AND AUXILIARY DIAGRAMS FOR DETERMINATION OF THE COMPOSITION OF BIOTITE, HORNBLENDE AND RHOMBIC PYROXENES]: Mineralogicheskiy sbornik, no. 4, L'vov. geol. o-va.

Walker, T. and Collins, W. H., 1907, PETROLOGICAL STUDY OF SOME ROCKS FROM THE HILL TRACTS, VIZAGAPATAM DISTRICT, MADRAS PRESIDENCY: Ree, G. S. India v. 36, pp. 1-18.

Winchell, A. N., and Winchell, Horace, 1953, Opticheskaya mineralogiya [OPTICAL MINERALOGY]: IL.

Reference Section

RUSSIAN AND EAST EUROPEAN GEOLOGIC ACCESSIONS OF THE LIBRARY OF CONGRESS

This section is devoted to a listing of selected geologic items appearing in the two publications of the Library of Congress; Monthly Index of Russian Accessions, and East European Accessions Index. These lists are intended as a means of indicating to researchers in the earth sciences some of the material most recently available for screening, further review, and translation. For this reason the lists do not include material now, or soon to be, published in English. Emphasis is placed on Russian material; the extent to which items from East European sources are listed depends on the country and language involved.

A major function of the AGI translations program is the screening of foreign literature for material that should be made available to the English-speaking scientist. Researchers who need such material are urged to review these lists and send us their recommendations for consideration by the editors; the translation needs of all geologists will be served better thereby.

-- Managing Editor

MONTHLY INDEX OF RUSSIAN ACCESSIONS

Volume 13, No. 10 January 1961

PART A—MONOGRAPHIC WORKS

12. GEOGRAPHY & GEOLOGY

ADREIANOV, V. G. [Annual distribution of streamflow; basic principles and their application to hydrological calculations and the water economy] Vnutrigodovoe raspredelenie rechnogo stoka; osnovnye zakonomernosti i ikh ispol'zovanie v gidrologicheskikh i vodokhoziaistvennykh raschetakh. Pod red. D. L. Sokolovskogo. Leningrad, Gidrometeor. izd-vo, 1960. 326 p.

AKADEMIIA NAUK KAZAKHSKOI SSR, Alma-Ata. [The problem of water supply in central Kazakhstan] Problema vodoobespecheniia TSentral'nogo Kazakhstana; sbornik statei. Pod red. Sh. Ch. Chokina i V. A. Kiktenko. Alma-Ata, 1960. 364 p.

AKADEMIIA NAUK SSSR. Vostochno-Sibirskii filial, Irkutsk. [Materials for the young scientists' conference dedicated to the 10th anniversary of the West Siberian Branch of the Academy of Sciences of the U. S. S. R.] Materialy k konferentsii molodykh nauchnykh sotrudnikov; k 10-letiiu Vostochno-Sibirskogo filiala AN SSSR. Irkutsk.
No. 1. [Geology and geography] Geologiia i geografiia. 1958. 153 p.

DUVANIN, A. I. [Sea tides] Prilivy v more. Leningrad, Gidrometeor. izd-vo, 1960. 389 p.

FEDOROV, V. V. [Hydrology and investigation of waters] Gidrologiia i vodnye izyskaniia. Leningrad, Izd-vo "Rechnoi transport," Leningr. otd-nie, 1960. 344 p.

GEOGRAFICHESKOE OBSHCHESTVO SSSR. [Geomorphology] Geomorfologiia. Moskva, Gos. izd-vo geogr. lit-ry, 1959. 269 p.
(DC)

INTERNATIONAL GEOLOGICAL CONGRESS, 21st, Copenhagen, 1960. [Determination of the absolute age of Pre-Quaternary geological formations] Opredelenie absoliutnogo vozrasta dochetvertichnykh geologicheskikh formatsii. Moskva, Izd-vo Akad. nauk SSSR, 1960. 251 p. (Doklady sovetskikh geologov. Problema 3) [In Russian with summaries in English.]

INTERNATIONAL GEOLOGICAL CONGRESS. 21st, Copenhagen, 1960. [Granite-gneiss] Granito-gneisy. Kiev, Izd-vo Akad. nauk USSR, 1960. 174 p. (Doklady sovetskikh geologov. Problema 14) [In Russian with summaries in English.]

INTERNATIONAL GEOLOGICAL CONGRESS. 21st, Copenhagen, 1960. [Late Pre-Cambrian and Cambrian stratigraphy] Stratigrafiia pozdnego dokembriia i kembriia. Moskva, Izd-vo Akad. nauk SSSR, 1960. 207 p. (Doklady sovetskikh geologov. Problema 8) [In Russian with summaries in English.]

INTERNATIONAL GEOLOGICAL CONGRESS. 21st, Copenhagen, 1960. [Structure of the earth's crust and the deformation of rocks] Struktura zemnoi kory i deformatsii gornykh porod. Moskva, Izd-vo Akad. nauk SSSR, 1960. 239 p. (Doklady sovetskikh geologov. Problema 18) [In Russian with summaries in English.]

KIRILLOVA, I. V., and others. [Analysis of the geotectonic development and seismicity of the Caucasus] Analiz geotektonicheskogo razvitiia i seismichnosti Kavkaza. Moskva, Izd-vo Akad. nauk SSSR, 1960. 339 p.

KONFERENTSIIA PO RAZVITIIU PROIZVODITEL'NYKH SIL VOSTOCHNOI SIBIRI, 1958. [Geology; transactions of the Conference on the Development of Productive Forces of Eastern Siberia] Geologicheskoe stroenie. [Trudy konferentsii.] Moskva, Izd-vo Akad. nauk SSSR, 1960. 152 p. (Razvitie proizvoditel'nykh sil Vostochnoi Sibiri)

LENINGRAD. VSESOIUZNYI GEOLOGICHESKII INSTITUT. [New species of ancient plants and invertebrates of the U. S. S. R.] Novye vidy drevnikh rastenii i bespozvonochnykh SSSR. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geol. i okhrane nedr.
Pt. 2. 1960. 521 p., illus.

MOSCOW. VSESOIUZNYI PROEKTNO-IZYSKATEL'SKII I NAUCHNO-ISSLEDOVATEL'SKII INSTITUT "GIDROPROEKT IMENI S. IA. ZHUK. [Geology of the Volga-Don Canal Region] Geologiia raiona sooruzhenii Volgo-Dona. Pod red. V. D. Galaktionova. Moskva, Gos. energ. izd-vo, 1960. 416 p. fold. col. map.

MURATOV, M. V. [Outline of the geology of the Crimean Peninsula] Kratkii ocherk geologicheskogo stroeniia Krymskogo poluostrova. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geologii i okhrane nedr, 1960. 206 p.

OBRUCHEV, V. A. [Selected works] Izbrannye trudy. Moskva, Izd-vo Akad. nauk SSSR.
Vol. 2. 1960. 503 p.

ORLOV, IU. A., ed. [Fundamentals of paleontology; manual in fifteen volumes for paleontologists and geologists of the U.S.S.R.] Osnovy paleontologii; spravochnik dlia paleontologov i geologov SSSR v piatnadtsati tomakh. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geol. i okhrane nedr.
[Vol. 4.] [Mollusks: Gastropoda] Molliuski - briukhonogie. Otvet red. V. F. Pchelintsev i L. A. Korobkov. 1960. 359 p.

PESCHANSKII, L. S. [Ice, a grain of sand, and the sun] Led, peschinka i solntse. Moskva, Izd-vo "Morskoi transport," 1960. 120 p.

[PHILOSOPHICAL PROBLEMS OF NATURAL SCIENCE] Filosofskie voprosy estestvoznaniia. [Moskva] Izd-vo Mosk. univ.
Vol. 3. [Geological and geographical sciences] Geologo-geograficheskie nauki. 1960. 468 p.

SHULEIKIN, V. V. [Research on the physics of oceans and seas] Fizicheskie issledovaniia okeanov i morei. Moskva, Izd-vo "Znanie," 1960. 39 p. (Vsesoiuznoe obshchestvo po rasprostraneniiu politicheskikh i nauchnykh znanii. Ser. 9, Fizika i khimiia, no. 18)

SOKOLOV, V. A. [V. M. Timofeev, explorer of Karelian mineral resources; life and work, 1884-1935] Issledovatel' nedr Karelii V. M. Timofeev; ocherki o zhizni i deiatel'nosti, 1884-1935 gg. Petrozavodsk, Gos. izd-vo Karel'skoi ASSR, 1960. 98 p.

VERNADSKII, V. I. [Selected works] Izbrannye sochineniia. Moskva, Izd-vo Akad. nauk SSSR.
Vol. 4. Book 2. 1960. 651 p.

VLADIMIROV, A. G. [Hydrogeology in land reclamation; hydrogeological investigations and measures for land reclamation in the arid zone] Meliorativnaia gidrogeologiia; meliorativno-gidrogeologicheskie issledovaniia i meropriiatiia v zasushlivoi zone. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geologii i okhrane nedr, 1960. 174 p.

VSESOIUZNAIA OB"EDINENNAIA SESSIIA PO ZAKONOMERNOSTIAM RAZMESHCHENIIA POLEZNYKH ISKOPAEMYKH I PROGNOZNYM KARTAM. 2d, Kiev, 1960. [Characteristics of the distribution of deposits in platform covers; reports] Zakonomernosti razmeshcheniia mestorozhdenii v platformennykh chekhlakh; doklady. Kiev, Izd-vo Akad. nauk USSR.
Pt. 2. 1960. 191 p.

13. SCIENCE

BARSUKOV, O. M., and V. A. TROITSKAIA. [Soviet stations for earth currents] Sovetskie stantsii zemnykh tokov. Moskva, 1959. 21 p.

16. TECHNOLOGY

ATSAGORTSIAN, Z. A., and O. A. MARTIROSIAN. [Tuffs and marbles of Armenia. Tufy i mramory Armenii. Erevan, Armianskoe gos. izd-vo] 1959. 141 p. [In Armenian.]

BEZRUCHKO, V. S. [Fundamentals of geodesy] Osnovy geodezii. Moskva, Vses. izdatel'sko-poligr. ob"edinenie M-va putei soobshcheniia, 1960. 178 p.

BYKHOVER, N. A. [Mineral resources of capitalist countries] Mineral'nye resursy kapitalisticheskikh stran. Moskva, Gosplanizdat, 1960. 274 p.

EPSHTEIN, E. F., E. I. ARSH, and G. K. VITORT. [New methods of rock breaking] Novye metody razrusheniia gornykh porod. Moskva, Gos. nauchno-tekhn. izd-vo neft. i gorno-toplivnoi lit-ry, 1960. 85 p.

GORSKII, N. N. [The energy and mineral wealth of seas in the service of mankind] Energiia i khimicheskie bogatstva morei na sluzhbe u cheloveka. Leningrad, Gidrometeor. izd-vo, 1960. 96 p.

MARKOV, P. N. [Prospecting for mica deposits] Kak iskat' mestorozhdeniia sliud. Izd. 2. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geol. i okhrane nedr, 1959. 19 p. (Bibliotechka uchastnika geologicheskogo pokhoda)

MEZHIBORSKAIA, KH. B., V. I. SHASHKIN, and I. P. SHUMILIN. [Analysis of radioactive ores by the β and γ method] Analiz radioaktivnykh rud β - γ - metodom. Moskva, Izd-vo Glav. uprav. po ispol'zovaniiu atomnoi energii pri Sovete Ministrov SSSR, 1960. 63 p.

MURASHKO, M. G., and others. [Cadastral survey of water-power resources of the White Russian S. S. R.; potential hydroelectric power resources] Vodnoenergeticheskii kadastr Belorusskoi SSR; potentsial'nye gidroenergoresursy. Pod red. T. L. Zolotareva. Minsk, Izd-vo Akad. nauk BSSR.
Vol. 1. 1960. 281 p.
___ ___ ___ maps.

PETROV, G. I., and others. [Methods of geological and geophysical exploration and control in uranium mines] Metody geologo-geofizicheskogo obsluzhivaniia uranovykh rudnikov. Moskva, Izd-vo Gos. kom-ta Soveta Ministrov SSSR po ispol'zovaniiu atomnoi energii, 1960. 217 p.

RUPPENEIT, K. V., and IU. M. LIBERMAN. [Introduction to rock mechanics] Vvedenie v mekhaniku gornykh porod. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po gornomu delu, 1960. 355 p.

RUSSIA (1923- U. S. S. R.) Ministerstvo geologii i okhrany nedr. [Angara-Ilim iron ore deposits of trap formation in the southern Siberian Platform] Angaro-Ilimskie zhelezorudnye mestorozhdeniia trappovoi formatsii iuzhnoi chasti Sibirskoi platformy. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po geol. i okhrane nedr, 1960. 375 p.

VYMORKOV, B. M., and N. P. PUTNIK. [Geothermal resources and their use in power engineering] Geotermicheskie resursy i ikh energeticheskoe ispol'zovanie. Moskva, Gos. energ. izd-vo, 1960. 166 p.

EAST EUROPEAN ACCESSIONS INDEX LIST

Volume 10, No. 1 January 1961

B U L G A R I A

12. GEOGRAPHY & GEOLOGY

PERIODICALS

Bulgarsko geologichesko druzhestvo. SPISANIE. REVIEW. Sofiia. [Bulletin issued by the Bulgarian Geological Society; with English, French, or German summaries. Three no. a year]

Vol. 21, no. 1, 1960.
- Bogdanov, B. Rare elements in lead-zinc ores from the district of Madan. p. 1.
- Stoikov, S. The pliocene in Vidin and Kula Districts. p. 28.
- Tsankov, V. On the stratigraphic level of some Urgonian Pachyodonta in Bulgaria. p. 38.
- Kostov, I. Pseudomalachite and plumbogummite, new minerals for Bulgaria. p. 75.

Karaguleva, IU. Eocene in the Lukovit syncline. p. 78.
Zaprianova, N.; Khristova, R. Cosalite of Gotse Delchev District. p. 80.
Boiadzhiev, S.; Sapundzhieva, V. Pliocene in the Palakariia, Samokov District. p. 86.
Gnoevaia, N.; Giurov, N. Siderite from Sheshkingrad, Slivev District. p. 93.
Khaidutov, Iv.; IAnev, S. Preliminary report on crystalline and magma rocks in a section of the Surnena sredna gora Mountains. p. 100.
Belmustakov, E. Paleocenic sediments in the Mominsko ploskogorie, Varna District. p. 106.
Koiumdzhieva, E. Presence of buglovien layers in northwest Bulgaria. p. 109.

16. TECHNOLOGY

PERIODICALS

MINNO DELO. (Ministerstvo na tezhkata promishlenost) Sofiia. [Journal on mining issued by the Ministry of Heavy Industry. Bimonthly]
Recurrent feature: Criticism and bibliography.

Vol. 15, no. 1, Jan. 1960.
Konstantinova, V. General information on the petrographic type of coal from the Balkan coal basin. p. 4.
Dobrev, T. Notes on the possibility of finding fire clay in Pleven District by means of electric surveying methods. p. 7.

vol. 15, no. 2, Feb. 1960.
Panov, P.; Andreev, G.; Vulev, T. Hydrogeological sketch of the 4th Section at Deveti septemvri Mine of Cherno more State Mining Enterprise. p. 3.
Dimitrov, R.; Petkov, I. Some questions on the geology of the Ardino-Momchilov Mining Region. p. 6.

Vol. 15, no. 3/4, Mar./Apr. 1960.
Bogdanov, B. Prospectives for finding new lead-zinc metasomatic deposits in the Madan ore region. p. 3.
Petrov, B. A new unified classification of rocks in the mining industry. p. 20.
New tariff tables, wage scales, and unified standards for the mining industry and the geological surveys. p. 33.
Some economic problems in the geologic research work in the Soviet Union. p. 43.

Vol. 15, no. 5, May 1960.
Minchev, I.; Kozarov, A. Photoelastic and photoelectric investigation into the influence of the anisotropy of mine massif on the distribution of the pressure in the vicinity of the open mine shaft. p. 20.

CZECHOSLOVAKIA

12. GEOGRAPHY & GEOLOGY

PERIODICALS

ZAJICEK, V. Vztahy povrchovych a podzemnich poricnich vod. Bratislava, Vydavatelstvo Slovenskej akademie vied, 1960. 175 p. [The relation between surface water and river basin underground water. German and Russian summaries. illus., bibl., diagrs., tables]

GEOLOGICKE PRACE; ZPRAVY. (Slovenska akademia vied. Geologicky ustav Dionyza Stura) Bratislava. [Research reports issued by the Dionyz Stur Geologic Institute, Slovak Academy of Sciences; with German and Russian summaries]

No. 17, 1960.
Bystricky, J. Geology of the Slovak Karst Mountains; the area between Silica and Domica. p. 5.
Lesko, B. Development of the menilite beds in the Slovak Carpathian Mountains. p. 29.
Durkovic, T. Petrography of the Krosno and Magura Flysch in eastern Slovakia. p. 51.
Pagac, I. Geology of the Lower and Upper Miocene of the Vienna basin in the area of Petrova ves, Stefanov, and Smolinske. p. 81.
Kubiny, D. Geology of the environs of Tragoska. p. 105.
Ctyroky, P. The Upper Burdigalian fauna on the Winterberg hill near Skalice in western Slovakia. p. 115.
Hanzlikova, E.; Mencik, E.; Pesl, V. The Upper Cretaceous Flysch beds in the klippen belt near Hanusovce nad Toplou. p. 135.
Zyka, V.; Vtelensky, J. Geochemistry of the Slovak travertine. p. 147.
Cicel, B. Halloysite and montmorillonite in the tuffite from Sobrance. p. 197.
Orvan, J. Origin of the mineral waters at Safarikova. p. 203.

13. SCIENCE

PERIODICALS

Ceskoslovenska akademie ved. Brnenska zakladna. PRACE. Brno. [Papers on natural sciences issued by the Brno Branch, Czechoslovak Academy of Sciences; with English, French, German, and Russian summaries. Superseded Moravskoslezska akademie ved prirodnich. Prace, 1954, and continues its vol. numbering. Twelve no. a year]

Vol. 32, no. 9, 1960.
Frejkova, L. The Cretaceous formation between Svitavy and Letovice. p. 365.

Ceskoslovenska akademie ved. ROZPRAVY. RADA MATEMATICKYCH A PRIRODNICH VED. Praha. [Transactions on mathematics and the natural sciences issued by the Czechoslovak Academy of Sciences. In Czech, English, French, German, or Russian with summaries in a language different from that of the article. Title varies slightly. Superseded Ceska akademie ved a umeni. Trida 2. Rospravy and continued its vol. numbering]

Vol. 70, no. 11, 1960.
Rohlich, P. Ordovician of the northeastern part of Prague. p. 1.

Vol. 70, no. 12, 1960.
Kukal, Z. Genetic types of stratification of the lower Paleozoic rocks of the Barrandian area. p. 3.

GEODETICKY A KARTOGRAFICKY OBZOR. (Ustredni sprava geodesie a kartografie) Praha. [Journal issued by the Central Geodetic and Cartographic Administration. Includes a supplement: Prehled zememericke literatury, documentation on surveying issued by the Central Research Institute of Geodesy, Topography, and Cartography. Superseded Zememerictvi, 1955. Monthly]
Recurrent features: Bibliography; Abstracts; Laws and regulations.

Vol. 6, no. 11, Nov. 1960.
Pravda, J. Shaded terrain and its reproduction in the USSR. p. 207.

16. TECHNOLOGY

PERIODICALS

UHLI. (Ministerstvo paliv) Praha. [Publication on coal mining and its economics issued by the Ministry of Fuel. Superseded a publication of the same title and absorbed Mistri hornicke prace, 1959. Former Uhli superseded in part Uhli a rudy, 1953, and continued its vol. numbering. See also Rudy. Monthly]
Recurrent feature: Information of the Ministry.

Vol. 2, no. 11, Nov. 1960.
Rybak; Holub. Drainage in the south Moravian lignite basin. p. 281.
Vavre, M. Production of waste rocks and their use for filling. p. 285.
Vrba, J. Hydrogeological mapping. p. 343.

VODNI HOSPODARSTVI. (Ministerstvo energetiky a vodniho hospodarstvi a Vedecka technicka spolecnost pro vodni hospodarstvi) Praha. [Journal on water resources policy and hydraulic engineering issued by the Ministry of Power and Water Resources Economy and the Scientific Technical Society for Water Resources Economy. Monthly]

Recurrent features: Suggestions for improvement; New books.

No. 8, Aug. 1960.

Experience in storing underground water. p. 365.

No. 9, Sept. 1960.

Zima, K. Underground water in the limestone formations of the Policka area. p. 372.

ESTONIA

16. TECHNOLOGY

PERIODICALS

GORIUCHIE SLANTSY, KHIMIIA I TEKHNOLOGIIA. (Eesti NSV Teaduste Akadeemia. Keemia Instituut) Tallinn. [Papers on the chemistry and technology of oil shale issued by the Institute of Chemistry, Estonian Academy of Sciences. In Russian with Estonian and English or German summaries]

No. 3, 1959.

Degtereva, Z.; Fomina, A. Influence of concentrated nitric acid on the kerogen of kukersite shale at room temperatures. p. 5.

Alumae, T. Some physicochemical indexes of karst phenomena in Estonian shale basin. p. 15.

Kniga, M.; Mishchenko, K. Heat effects caused by influencing kukersite shale with water and organic solvents. p. 21.

Rikken, J. The low-temperature decomposition of kukersite shale. p. 31.

Milk, A. Thermal decomposition of kukersite lump shale. p. 39.

Koll, A.; Gubergrits, M.; Aherma, H. Thermostability of kukersite shale. p. 57.

Koll, A.; Laus, T.; Elenurm, A. Thermal processing of Dictyonema shale with a solid-heat carrier. p. 69.

Elenurm, A. Behavior of the various forms of sulfur of the Dictyonema shale by thermal processing with a solid heat-carrying agent. p. 77.

Gubergits, M. On improving lump shale retorting technology. p. 88.

Stepanov, I. Study of the electrothermal process of the decomposition of shale. p. 96.

Paalme, L. The distribution of air and gas flows in the underground gasification of shale with the application of the combined method. p. 105.

Gubergrits, M. Heat transfer phenomena and the combined method of the underground gasification of shale. p. 122.

Brodskaia, B. Study of the application of electric current by the underground gasification of shale in the experimental panel no. 3. p. 137.

Gubergrits, M.; Kuiv, K. On the theory of heat-transfer calculation in kukersite shale retorting. p. 153.

Gubergrits, M.; Paalme, L. Investigation, with the use of models, of moving granular material in vertical shale retorting reactors. p. 165.

Koll, A.; Stepanov, I. Characteristics of the gas obtained by processing shale in an installation with a solid heat-carrying agent. p. 176.

Koll, A., and others. Effect of the temperature of the thermal decomposition of shale on the group composition of shale oil. p. 185.

Koll, A., and others. On the group composition of shale oil produced in a semi-industrial installation equipped with a solid heat-carrying agent in Kivioli. p. 197.

Eisen, O.; Kivirahk, S.; Laus, T. Results of the investigation of the chemical composition of Dictyonema oil obtained from a processing plant using a solid heat-carrying agent. p. 205.

Kudriavtsev, I. Investigation of dephenolized shale oil, fraction 250-350^{o}, obtained from a processing plant with a solid heat-carrying agent. p. 213.

Fomina, A.; Zolotarevskaia, M. Chemical composition of the hydrocarbons of the medium fractions of the oil from panel no. 4. p. 223.

Klesment, I. Separation of aromatic hydrocarbons from aromatic shale benzine through extraction. p. 240.

Koll, A.; Faingold, S.; Stepanova, G. The treatment by two-stage polymerization of light fractions of shale oil obtained in the pilot plant with a solid heat-carrying agent. p. 251.

Koll, A., and others. Synthesis of detergents from the type of alkyl aryl sulfonamides from shale oil. p. 260.

Faingold, S.; Korv, M. On the duration of catalytic processing of light fractions of shale oil. p. 272.

Horak, E. Thermocatalytic changes in neytral oxygen compounds of the medium fractions of shale oil. p. 281.

Lozovoi, A.; Stepanova, G. Processing of shale generator oil into motor fuels by the method of two-stage hydrogenation and catalytic cracking. p. 299.

Faingold, S.; Vallas, K. Cracking of shale generator oil with zinc chloride. p. 312.

Koll, A.; Liiv, E. Peculiarities of the oxidation process of the heavy fractions of shale oil. p. 325.

HUNGARY

16. TECHNOLOGY

PERIODICALS

ACTA TECHNICA. (Magyar Tudomanyos Akademia) Budapest. [Transactions on technical sciences issued by the Hungarian Academy of Sciences. In English, French, German, and Russian with summaries in a language different from that of the article]

Vol. 30, no. 1/2, 1960.

Regoczi, E. Geodetic works in Hungary. In French. p. 5.

Renner, J. Gravity research in Hungary in the years 1957 through 1959. In English. p. 11.

Egyed, L. Investigations on seismology and the physics of the interior of the earth in Hungary, 1957-1959. In English. p. 15.

Bell, B. Main results of meteorological research done in Hungary during the years 1957-1959. In English. p. 29.

Barta, Gy. Report on geomagnetic and earth current research in Hungary in the period 1957 through 1959. In English. p. 53.

Nemeth, E. Hydrologic research in Hungary. In French. p. 59.

Panto, G. Investigations in connection with volcanology in Hungary, 1957-1959. In English. p. 89.

BANYASZATI LAPOK. (Magyar Banyaszati es Kohaszati Egyesulet) Budapest. [Journal on prospecting and mining issued by the Hungarian Mining and Metallurgic Society. Includes a supplement: Koolaj, on crude oil production. Monthly]

Recurrent features: Foreign news; News from the Society; Book reviews.

Vol. 93, no. 10, Oct. 1960.

Eszto, P. Dimensioning conveyer belts. p. 657.

Szirtes, L. New methods of preventing gas outburst in the coal mines of Pecs. (To be contd.) p. 660.

Kaszap, A. A search for raw materials in Poland. p. 675.

T. M. Specifically effective method of developing production techniques in coal mining. p. 676.

free. Mineral resources of Denmark. p. 680.

free. Nuclear metals in capitalist countries. p. 680.

Ajtay, Z. Safety dam systems for protection against inrushes of water. p. 681.

Fabiancsics, L. Possibilities of deep-boring geophysics in the coal basin of Nograd-Borsod. p. 693.

Mraz, E. Basic principles of the Czechoslovak mining law. Tr. from the Czech. p. 698.

Kaszap, A. The new European oil pipelines. p. 702.

Kassai, L. Evaluation of the curves of pressure increase in oil producing wells. (To be contd.) p. 703.

MUSZAKI ELET. (Muszaki es Termeszettudomanyos Egyesuletek Szovetsege) Budapest. [Publication on technology and production issued by the Federation of Technical and Scientific Associations. Title varies: before v. 10, 1955, Magyar Technika. Semimonthly]

Vol. 15, no. 20, Sept. 1960.

Suloky, I. The geomagnetic observatory in Baja. p. 11.

LITHUANIA

12. GEOGRAPHY & GEOLOGY

PERIODICALS

Lietuvos TSR Mokslu akademija. Geologijos ir geografijos institutas. MOKSLINIAI PRANESIMAI. Vilnius [Papers issued by the Institute of Geology and Geography, Lithuanian Academy of Sciences. In Lithuanian and Russian with summaries in the language different from that of the article]

Vol. 10, no. 2, 1959.
- Racinskas, A. Seasonal rhythm of slope erosion in the hills of East Lithuania. p. 5.
- Micas, L. The structure of Neman River valley in the area of Merkine-Prienai. p. 27.
- Gaigalas, A. Petrographic characteristics of pebble fraction of Neopleistocene and Mesopleistocene moraines in the middle course of the Neman River. p. 47.
- Gaigalas, A. Petrographic problem of erosion crust of Mesopleistocene moraines in the middle course of the Neman River. p. 69.
- Cepulyte, V. Main characteristics of the relief of Lithuanian lower and upper Pleistocene and Subquaternary. p. 81.
- Vasiliauskiene, M. Peculiarities of littorals in lakes of different genetic types in the hill of Suduva. p. 19.
- Klimkaite, I. Hydrochemical and thermal system of Kryzuociai Lake. p. 115.
- Kondratiene, O. Interglacial formations in Valakampiai and Buivydziai. p. 151.
- Vasiliauskas, V. Structural problem of the glacial dislocations near Grodno. p. 163.
- Kabailiene, M. Development of the Baltic shore of Lithuania and southern Latvia during the late Glacial and post-Glacial period according to the results of diatomaceous flora research. p. 175.
- Grigelyte, M. The problem of stratification and expansion of cotton-grass peat in Lithuania. p. 215.
- Garunkstis, A.; Stanaitis, A. Concerning the origin of Dusia, Metelis and Obelija Lakes. p. 235.
- Mikaila, V. The structure and lithologic characteristics of more important Lithuanian limnoglacial basins. p. 249.

13. SCIENCE

PERIODICALS

Lietuvos TSR Mokslu akademija. DARBAI. SERIJA B. TRUDY. SERIIA B. Vilnius. [Papers on pure and applied sciences issued by the Lithuanian Academy o Sciences. In Lithuanian and Russian. Superseded, in part, its Zinynas, 1955. See also its Darbai. Serija A]

No. 2, 1960.
- Zukaite, E. Some morphometrical characteristics of the Svogine Lake in various stages of its development. p. 181.
- Kesminas, A. The problem of determining the optimum depth of wear of a dam for a hydroelectric-power station. p. 191.

16. TECHNOLOGY

PERIODICALS

Kaunas. Politechnikos institutas. DARBAI. TRUDY. Kaunas. [Papers on technical science issued by the Kaunas Polytechnic Institute. In Lithuanian or Russian with a summary in the language different from that of the articla]

Vol. 10, no. 1, 1958.
- Vasauskas, S.; Aukstakalnis, P. The process of the formation of an impression by pressing a conic indentor into steel. p. 3.
- Slavenas, J. Problem of determining the scale coefficient in the case of changing loads. p. 7.
- Tulevicius, V. Accuracy of topographic and geodetic works in draining swampy areas. p. 11.
- Palukaitis, D. Pulsation of hydrodynamic pressure at the border of a flow and its connection with the flow structure. In Russian. p. 19.
- Lukosiunas, C. Influence of a repeated load on ground deformation. In Russian. p. 27.
- Gudanecas, A. Boulders of southern Lithuania and their utilization in the construction industry. In Russian. p. 33.

POLAND

12. GEOGRAPHY & GEOLOGY

GALON, RAJMUND, ed. Wydmy srodladowe Polski. [Wyd. 1.] Warszawa, Panstwowe Wydawn. Naukowe. [The continental sand dunes of Poland. 1st ed. French summary. illus., maps (part fold.), bibl., diagrs., footnotes, tables]
Vol. 1. 1958. 203 p.

KOWALSKA, ANNA. Paleomorfologia powierzchni podplejstocenskiej nizowej czesci dorzecza Odry. [Wyd. 1.] Warszawa, Panstwowe Wydawn. Naukowe, 1960. 75 p. (Polska Akademia Nauk. Instytut Geografii. Prace geograficzne, nr. 21) [Paleomorphology of the sub-Pleistocene surface of the lowland part of the Oder River basin. 1st ed. English and Russian summaries. maps (fold. in pocket), bibl., profiles, tables]

POLSKA AKADEMIA NAUK. Instytut Geografii. Morfologia i hydrografia. Warszawa, 1959. 62 p. (Dokumentacja geograficzna, zesz. 6) [Morphology and hydrography. German summary. maps (part fold.), bibl., footnotes, tables]

RABOWSKI, FERDYNAND. Serie wierchowe w Tatrach Zachodnich. High-Tatric series in Western Tatra. [Wyd. 1.] Warszawa, Wydawn. Geologiczne, 1959. 178 p. (Warsaw. Instytut Geologiczny. Prace, t. 27) [1st ed. English and Russian summaries. illus., 16 plates, col. maps, footnotes, col. profiles. Part of illustrative matter in pocket]

ROTNICKI, KAROL. Oz Bukowsko-Mosinski. [Wyd. 1.] Poznan, [Panstwowe Wydawn. Naukowe] 1960. 165 p. (Poznanskie Towarzystwo Przyjaciol Nauk. Komisja Geograficzno-Geologiczna. Prace, t. 2, zesz. 2) [The Buk-Mosina esker. 1st ed. English summary. illus., maps (part fold.), bibl., footnotes, graphs, profiles]

SKORUPA, JAN. Morfologia podloza magnetycznie czynnego i podloza krystalicznego w polnocno-wschodniej Polsce. Morphology of the magnetically active basement and of crystalline basement in north-eastern Poland. [Wyd. 1.] Warszawa, Wydawn. Geologiczne, 1959. 51 p. (Warsaw, Instytut Geologiczny. Biuletyn, 160. Seria geofizyczna, nr. 19) [1st ed. English and Russian summaries. map (fold. in pocket), bibl., footnotes]

SMOLSKA, ANNA. W jakich drewnach kopalnych kryja sie sosny koninskie. [Wyd. 1.] Warszawa, Wydawn. Geologiczne, 1959. 86 p. (Warsaw. Instytut Geologiczny. Prace, t. 29) [The fossil wood in which Konin pines may be found. 1st ed. German and Russian summaries. 14 plates, diagrs., tables]

WARSAW. INSTYTUT GEOLOGICZNY. Dzialalnosc Instytutu Geologicznego w 1956 i 1957 roku. [Wyd. 1.] Warszawa, Wydawn. Geologiczne, 1959. 175 p. (Its Biuletyn, 148) [Activities of the Institute of Geology in the years 1956 and 1957. 1st ed. maps (part fold.), diagrs., tables]

WARSAW. INSTYTUT GEOLOGICZNY. Katalog analiz chemicznych skal i mineralow Polski. Opracowali Jan Czerminski et al. Warszawa, Wydawn. Geologiczne. (Its Prace, t. 25) [Catalog of chemical analysis of rocks and minerals of Poland. fold. maps (in pocket), bibl., footnotes, indexes, tables]
Vol. 1. [1900-1950] 1959. 155 p.

WARSAW. INSTYTUT GEOLOGICZNY. Z badan geologicznych regionu swietokrzyskiego. From the geological researches in the Swiety Krzyz Mts. region [i.e. Gory Swietokrzyskie] [Wyd. 1.] Warszawa, Wydawn. Geologiczne. (Its Biuletyn, 159) [1st ed. English and Russian summaries. maps, bibl., footnotes, profiles, tables]
Vol. 3. 1959. 157 p.

WARSAW. INSTYTUT GEOLOGICZNY. Z badan geologicznych wykonanych w Tatrach i na Podhalu. From geological researches in the Tatra Mountains and in the Podhale region. [Wyd. 1.] Warszawa, Wydawn. Geologiczne. (Its Biuletyn, 149) [1st ed. English and Russian summaries. maps, bibl., diagrs., footnotes, profiles, tables. Part of illustrative matter in pocket]
Vol. 5. 1959. 277 p.

WARSAW. INSTYTUT GEOLOGICZNY. Z badan struktur podloza Polski. Investigations of the substratum structures of Poland. [Wyd. 1.] Warszawa, Wydawn. Geologiczne. (Its Biuletyn, 140) [1st ed. English and Russian summaries. illus., map, bibl., diagrs., footnotes, profile. Part of illustrative matter in pocket]
Vol. 5. [Konior, Konrad, and Adam Tokarski. New deep key borehole south of Cieszyn] 1959. 79 p.

WARSAW. INSTYTUT GEOLOGICZNY. Z badan zloz kruszcow. From the ore deposits researches. [Wyd. 1.] Warszawa, Wydawn. Geologiczne. (Its Biuletyn, 161) [1st ed. English and Russian summaries. fold. map, bibl., footnotes, fold. profiles, tables. Part of illustrative matter in pocket]
Vol. 2. [Deczkowski, Zbigniew. Dogger between Wilkowiecko and Libidza] 1959. 71 p.

PERIODICALS

ACTA PALEONTOLOGICA POLONICA. (Polska Akademia Nauk. Komitet Geologiczny) Warszawa. [Journal on paleontology issued by the Committee on Geology, Polish Academy of Sciences. In English, French, Polish, and Russian with summaries in a language different from that of the article. Superseded in part Acta Geologica Polonica, 1956. Quarterly]
Vol. 5, no. 3, 1960.

KWARTALNIK GEOLOGICZNY. (Instytut Geologiczny) Warszawa. [Journal on the geology of Poland and related subjects issued by the Institute of Geology; with English and Russian summaries. Quarterly]
Vol. 3, no. 4, 1959.
Kuhl, J. The chemical and mineralogical structure of the inorganic mineral substance found in the brown coal of Konin. Pt. 1. Investigation of ashes. p. 751.
Juskowiak, O. Prospecting for deposits of rare metals by using the slick method in the eastern part of the Riesengebirge massif. p. 767.
Heflik, W. Petrography of the volcanic glass in bentonite clays from Ciecierze near Chimelnik. p. 778.
Kita, M, Ostrowicki, B. Copper mineralization at Monasterzec near Lesko in the Carpathian Mountains. p. 790.
Tarass, N.; Stajniak, J. Special aspects of the geoelectric survey at Mrzyglod near Zawiercie; the problem of vertical resistivity. p. 807.
Gorecka, T. On the Upper Devonian of the Nowa Wies region near Srebrna Gora in the Sudeten. p. 827.
Dziedzic, K. The comparison of Rothliegendes formations of the Nowa Ruda and Swierzawa regions in the Sudeten. p. 831.
Bojkowski, K. The stratigraphic position of sediments in the Golonag structural borehole in the Upper Silesian coal basin. p. 847.
Krysowska, M. Heavy minerals in carboniferous deposits from Boleslaw near Olkusz in the Upper Silesian coal basin. p. 857.
Alexandrowicz, Z. Carboniferous Foraminifers from Kozlowa Gora near Bytom in Upper Sileisa. p. 869.
Jachowicz, A. Spore associations and the stratigraphic position of coal seams at Kozlowa Gora in the Upper Silesian goal basin. p. 883.
Senkowiczowa, H. The stratigraphic position of the Rhaetic. p. 899.
Osika, R. Middle Lias sediments of Western Pomerania; in connection with the prospecting for iron-ore deposits. p. 914.
Karczewski, L. A new species of Gasteropoda from the Astartian limestones of Sulejow. p. 939.
Cieslinski, S. The beginning of the Upper Cretaceous in Poland except for the Carpathian Mountains and Silesia. p. 943.
Peszat, C. The silicification of Cieszyn limestones at Leszna Gora near Cieszyn. p. 965.
Skoczylas-Ciszewska, K.; Kamienski, M. The Inoceramus facies of the Istebna beds of the Wisnicz-Roznow region in the Carpathian Flysch. p. 977.
Koszarski, L.; Zytko, K. Remarks on the development and stratigraphic position of Jaslo shells of th the menilite and Krosno series of the Middle Carpathian Mountains. p. 996.
Jasionowicz, J.; Koszarski, L.; Szymakowska, F. Geologic conditions of the occurrence of phosphoritic concretions in the Weglowka variegated marls in the Upper Cretaceous of the Middle Carpathian Mountains. p. 1016.
Milewicz, J. Remarks on the tectonics of the Lwowek Slaski region. p. 1024.
Doktorowicz-Hrebnicka, J. Some pollen grains of the Taxodiaceae family in the Tertiary formations of the brown coal of Poland. Pt. 2. Investigation of the fossil material in comparison with the contemporary material. p. 1033.
Schoeneich, K. An attempt at a genetic classification of dunes from the Warsaw region. p. 1051.

13. SCIENCE

PAWLOWSKI, STANISLAW. Anomalie magnetyczne w Polsce. The magnetic anomalies in Poland. Warszawa, Panstwowy Instytut Geologiczny, 1947. 59 p. (Warsaw. Instytut Geologiczny. Biuletyn 44. Seria geofizyczna, nr. 2) [English summary. maps (part fold.), diagrs., footnotes, tables]

SKOWRON, STANISLAW, ed. O powstaniu zycia; hipotezy i teorie. Opracowali: Maria Jordan [et al. Wyd. 1.] Warszawa, Panstwowe Wydawn. Naukowe, 1957. 381 p. [The origin of life; hypotheses and theories. 1st ed. illus.]
DNLM Not in DLC

SZAFER, WLADYSLAW. Rodowody drzew w swietle ewolucji. Szczecin, [Panstwowe Wydawn. Naukowe] 1959. 15 p. (Szczecinskie Towarzystwo Naukowe. Wydzial Nauk Przyrodniczo-Rolniczych. [Prace] t. 1, zesz. 2) [Genealogy of trees in the light of evolution. illus., graph, table]

Borowiec, S. Some problems of paleopedology and pedogenesis in the light of new data. p. 233.

16. TECHNOLOGY

BRACH, IGNACY. Teoretyczne podstawy skrawania gruntow w maszynach do robot ziemnych. Warszawa, Arkady, 1960. 53 p. (Warsaw. Instytut Organizacji i Mechanizacji Budownictwa. Prace, r. 8, zesz. 34) [Theoretical basis for the problems of cutting soils by earthmoving machines. English, French, German, Polish, and Russian summaries. bibl., footnotes, graphs, tables]

PERIODICALS

CEMENT, WAPNO, GIPS. (Wydawnictwo "Budownictwo i Architektura") Krakow. [Publication on adhesives in the building industry issued by Building and Architectural Publications. Includes a supplement: Przeglad Bibliograficzny Materialow Wiazacych, bibliography on adhesives. Monthly]
Recurrent features: Editor's answers; News from the foreign press.

Vol. 15 (i.e. 16), no. 10, Oct. 1960.
Budnikow, P.; Butt, J. Hydrothermal hardening of buidling materials manufactured from new sorts of raw materials. p. 276.
Szpak, E. Agglopories as an excellent concrete aggregate. p. 278.
Michalowicz, M. Gravelite as a lightweight concrete aggregate. p. 292.

Vol. 16, no. 11, Nov. 1960.
Nizinski, S.; Beben, A. Utilization of the cleavage of rocks for work with explosives. Pt. 2. p. 313.

RUDY I METALE NIEZELAZNE. (Wydawnictwo Gorniczo-Hutnicze) Katowice. [Journal on the mining and processing of ores and the metallurgy of nonferrous metals issued by Minine-Metallurgic Publications; with English, German, and Russian summaries. Quarterly]

Vol. 5, no. 12, Dec. 1960.
Blitek, Z. Influence of the exploitation of ores upon surface deformations in the Beuthen basin. p. 501.
Gabrys, J. Exploitation of a disturbed lead- and zinc-ore deposit. p. 514.
Stepinski, W. Nomograph on the value of ore and concentrate. p. 520.

RUMANIA

12. GEOGRAPHY & GEOLOGY

POP, EMIL. Mlastinile de turba din Republica Populara Romina. [Bucuresti] Editura Academiei Republicii Populare Romine, 1960. 511 p. (Biblioteca de biologie vegetala) [Peat bogs of the Rumanian People's Republic. French and Russian summaries. illus., maps (part fold.), bibl., footnotes, graphs, indexes, tables]

13. SCIENCE

PERIODICALS

Academia Republicii Populare Romine. COMUNICARILE. Bucuresti. [Transactions on pure and applied sciences issued by the Rumanian Academy; with French and Russian summaries. Monthly]
Vol. 10, no. 2, Feb. 1960.
Tarnavschi, I.; Mitroiu, N. Palynological considerations regarding the representatives of the family Primulaceae in the flora of Rumania. p. 111.

Academia Republicii Populare Romine. Filiala Iasi. STUDII SI CERCETARI STIINTIFICE. CHIMIE. Iasi. [Journal on chemistry issued by the Iasi Branch, Rumanian Academy; with French and Russian summaries. Superseded in part, in 1956, and continues the vol. numbering of its Studii si cercetari stiintifice. Seria I: Stiinte matematice, fizice, chimice si tehnice, which superseded in part its Studii si cercetari stiintifice, July 1954. See also its Studii si cercetari stiintifice. Fizica si stiinte tehnice and its Studii si cercetari stiintifice. Matematica]
Vol. 10, no. 2, 1959.
Savul, M.; Movileanu, A. The Clarke distribution of manganese in the Triassic limestone of northern Dobruja. p. 207.
Savul, M.; Ababi, V. Contributions to the knowledge of the distribution of Cu, Co, Zn, and Pb in some soils of the mountainous region of Campulung-Moldovenesc. p. 229.
Simionescu, C.; Grigoras, M. On the variation of the main chemical components of some species of Rumanian trees. p. 323.

Academia Republicii Populare Romine. Institutul de Fizica. STUDII SI CERCETARI DE FIZICA. Bucuresti. [Journal issued by the Institute of Physics and Institute of Atomic Physics, Rumanian Academy; with French and Russian summaries. Quarterly]

Vol. 11, no. 1, 1960.
Atanasiu, G.; Pascu, M. Regional magnetic anomalies caused by Moldavian andesitic cinerites. p. 35.

Vol. 11, no. 2, 1960.
Fiti, M.; Mantescu, C.; Costea, T. Determination of boron in ores through the registration of particles in the reaction $B^{10}(n, \alpha) Li^7$. p. 423.
Gildau, E.; Valeriu, A. Measuring the distribution of the magnetic field by means of nuclear magnetic resonance. p. 462.

16. TECHNOLOGY

RUMANIA. Ministerul Industriei Petrolului si Chimiei. Regulament pentru prevenirea eruptiilor. Bucuresti, 1959. 58 p. [Regulation for avoiding petroleum eruptions]

PERIODICALS

HIDROTEHNICA. (Asociatia Stiintifica a Inginerilor si Tehnicienilor din Romina) Bucuresti. [Journal on hydraulic engineering issued by the Scientific Association of Engineers and Technicians of Rumania; with English, French, German, and Russian summaries. Resumed publication of the same title, which was suspended Mar. 1954-Dec. 1955(?) Monthly]
Recurrent feature: Documentation.

Vol. 5, no. 9, Sept. 1960.
Popescu, I. Fighting the losses of water in the irrigation canals. p. 313.
Cunitescu-Jianu, Gh.; Kellner, P. Contributions to the study of loess. p. 319.

METEOROLOGIA, HIDROLOGIA SI GOSPODARIREA APELOR. (Comitetul de Stat al Apelor de pe linga Consiliul de Ministri) Bucuresti. [Journal on meteorology, hydrology, and water resources management issued by the State Committee on Water Resources, Council of Ministers; with English, French, and Russian summaries. Title varies: v. 1-2, 1956-57, Meteorologia si hidrologia. Quarterly]
Vol. 5, no. 1, 1960.
Stanescu, V. Contributions to the hydrologic study of the channels in the Danube River Delta. p. 34.
Negrutiu, R. Some characteristics of the hydrologic studies necessary for the design and construction of bridges. p. 42.
Gistescu, P. Some data on the lakes of the Hungarian People's Republic with special emphasis on Lake Balaton. p. 48.
Nicolescu, M. Limestone; caves and the water flow in limestone. p. 61.
Besleaga, N. A method of computing the variation of the pressure upon the earth for a period of 24 hours, with the aid of the isobaric topographic charts T_{500} and TR^{500}_{1000} at the Bucuresti-Baneasa Station. p. 69.
Grigore, M. Monografia geografica a Republicii Populare Romine. Vol. I. Geografia fizica (Geographical Monograph of the Rumanian People's Republic, Vol. I. Physical Geography); a review. p. 71.

YUGOSLAVIA

12. GEOGRAPHY & GEOLOGY

PERIODICALS

Belgrade. Seizmoloski zavod. BULLETIN SEISMIQUE MENSUEL. Beograd. [Bulletin issued by the Seismologic Institute in Belgrade. In French. Title varies: before 1954, its Enregistrations Seismographiques. Monthly]
June-Aug. 1960.

16. TECHNOLOGY

BOGDANOVIC, LJUBOMIR. Odredivanje otpornosti tla na penetraciju. U Subotici, 1959. 61 p. (Institut za ispitivanje materijala NR Srbije. Odeljenje geomehanike. Publikacija, br. 14) [Determination of soil penetration resistance. English, French, German, and Russian summaries. illus., bibl., diagrs., graphs, tables]

PERIODICALS

RUDARSKO-METALURSKI ZBORNIK. (Ljubljana. Univerza. Fakulteta za rudarstvo, metalurgijo in kemijsko tehnologijo. Oddelek za rudarstvo in metalurgijo) Ljubljana. [Papers issued by the Department of Mining and Metallurgy, Faculty of Mining, Metallurgy, and Chemical Technology, University of Ljubljana; with English and German summaries. Quarterly]

No. 3, 1960.

- Hamrla, M. Development and stratigraphy of the productive Liburnian stratum of the littoral Karst. p. 203.
- Gregorac, F. Selective flotation of Pb-Zn ores with special regard to the flotation of cerussite. p. 217.
- Pelhan, C. Growth of graphite in cast iron. p. 227.
- Gogala, A. Prospective development of the mine and ironworks of Vares. p. 237.
- Loose, I. Development of the mine and ironworks of Vares up to the present time. p. 253.
- Ocepek, D. Separation problems of the iron ores of Vares. p. 265.
- Dobovisek, B.; Straus, B. Report on caloric measurements by thermodifferential analysis. p. 273.

VODOPRIVREDA JUGOSLAVIJE. (Savezna komisija za vodoprivredu) Beograd. [Papers issued by the Federal Commission on Water Resources; with English, French, and Russian summaries]

Vol. 2, no. 7/8, 1959.

- Bata, G. Friction losses on the surfaces of two liquid currents of different density. p. 9.
- Kresser, W. Importance of the theory of bordering layers in hydraulic constructions. In French. p. 13.
- Bozoky, K. New formula for calculating the flow of water of a thin layer; some problems from irrigation hydraulics concerning natural flows. p. 45.
- Benfratello, G. Experimental research concerning a river model with movable bed. In French. p. 54.
- Kalis, J. Movement of liquids carrying suspended sediments. In French. p. 73.
- Boor, B. Complex method of calculating the depth of the sinking basin in the system of bottom flows. In French. p. 79.
- Starosolszky, O.; Zsuffa, I. Some experiences in the study of the retention in the bed of the Danube River and the application of the transposition of the flood routing hydrogram. p. 85.
- Gyorke. Studying a flow model which in nature also has slow speed. p. 86.
- Puskas, G. Some opinions on the hydrologic dimensioning of water reservoirs. p. 88.
- Vukovic, M. Filtration toward a system of watercourses supplied with underground water under pressure. p. 244.
- Ihrig, D.; Ubell, K. Leakage under dams which are built for the protection against floods. p. 249.
- Olos, G. Detailed study of hydraulic conditions in the vicinity of the walls of a well. p. 250.
- Escande, L. Drainage siphon for solid deposits. In French. p. 252.
- Therese Bonafe, M. Contribution to the study of the overflowing brims of Krieger type in powerful flowing-down retention; effect of the bottom water against the upper water in flooded dams. p. 256.

LIST OF GEOLOGICAL TITLES FROM RUSSIAN PERIODICALS

The Library of Congress does not currently print the translated Tables of Contents of the periodicals indexed in the Monthly Index of Russian Accessions. By arrangement with the Library of Congress, its manuscript translated Tables of Contents are scanned by the IGR staff for titles of potential translation interest to geologists. Although this arrangement requires a different format, and the reporting of each Monthly Index's contents over two or more issues of IGR, it is assumed that this additional coverage is desirable and used. Suggestions for improving the service will be welcomed. --M. R.

MONTHLY INDEX OF RUSSIAN ACCESSIONS

Volume 13, No. 7 October 1960

Biul. MOIP. Otd. geol.
Moskovskoe obshchestvo ispytatelei prirody. Biulleten'. Otdel geologicheskii [Moscow Naturalists' Society. Bulletin. Geological Section] vol. 35, no. 1, Jan.-Feb. 1960.

Dokl. AN Azerb. SSR
Akademiia nauk Azerbaidzhanskoi SSR, Baku. Doklady [Academy of Sciences of the Azerbaijan S.S.R. Reports] vol. 16, no. 4, 1960.

zone. O. M. Makhan'kov. p. 339-362.
Plattnerite in lead-zinc ores of the Mekhmana deposit [in Azerbaijani with summary in Russian]. T. A. Khalilova. p. 363-366.
Presence of middle Albian sediments in the Buzlukhchay River basin (Lesser Caucasus). O. B. Aliev. p. 367-370.

az. prom.
Gazovaia promyshlennost' [Gas Industry] vol. 5, no. 7, 1960.

Methods of determining the behavior of gas fields during an edge water drive. T. Gol'dfrakht, P. Ionesku. p. 5-13.
Equilibrium constants of the components of natural gas in the system gas-petroleum. N. A. Trivus. p. 13-19.
Gas fields in Western Pakistan. IU. Gatenberger. p. 52-55.

eol. rud. mestorozh.
Geologii rudnykh mestorozdenii [Geology of Ore Deposits] no. 6, Nov.-Dec. 1959.

Exogenous processes in the formation of uranium deposits. A. G. Betekhtin. p. 5-26.
Uranium mineralization in carbonate sedimentary rocks. V. I. Danchev and others. p. 27-38.
Effect of enclosing rocks on ore deposition in hydrothermal deposits of uranium. G. A. Pelymskii. p. 39-51.
Classification of molybdenum deposits. N. A. Khrushchov. p. 52-67.
Using the X-ray spectrum method for local analysis of platinum minerals. I. B. Borovskii, A. N. Deev, I. D. Marchukova. p. 68-73.
Occurrence and composition of platinum minerals in ores of the Norl'sk deposit. A. D. Genkin. p. 74-84.
An instance of coke formation in coals in contact with a sulfide vein. E. N. Sukhanova. p. 85-89.
Deposition of barites and nonferrous metal sulfides in the Madneuli deposit. IU. I. Nazarov. p. 90-101.
Hydrothermal metamorphism of rocks enclosing lead-zinc and complex metal deposits in Georgia. T. V. Ivanitskii. p. 102-113.
New type of tin ores in dolomites of the Lesser Khingan Mountains. G. M. Konstantinov. p. 114-116.
Physical properties of pegmatites and enclosing rocks of Korelia and the Kola Peninsula. S. IA. Liogen'kii. p. 117-120.
Some remarks on A. G. Betekhtin's article "Behavior of radioactive elements in the formation of endogenous deposits." V. L. Barsukov, G. B. Naumov. p. 121-124.
Genesis of wolframite deposits in Transbaikalia. A. D. Shcheglov. p. 127-130.

Gidr. stroi.
Gidrotekhnicheskoe stroitel'stvo [Hydrotechnical Construction]

Vol. 30, no. 6, June 1960.
Determining the capacity of flood-control reservoirs with a calculation for seasonal regulation of streamflow. E. N. Podolskii, B. L. Baburin. p. 30-35.
Determining the pressure exerted on earth dams by compacting sediments. V. G. Korotkin, D. M. Tartakovskii, p. 35-40.
Estimating the resistance of a flashy stream in the zone of small relative depths. S. A. IAkhontov. p. 40-43.

Vol. 30, no. 7, July 1960.
Limiting the height reached by waves breaking on the flat slopes of earth structures. V. F. Kanarskii. p. 38-39.
Graphoanalytical method for plotting velocity fields of a uniform flow in case of a sudden unilateral widening of the channel. I. V. Lebedev. p. 39-43.
Velocity distribution across the channel width. IU. A. Ibad-Zade. p. 43-46.
Hydraulic calculations of natural mountain streams. V. S. Travinov. p. 47-48.

Inform. biul. NIIGA.
Leningrad. Nauchno-issledovatel'skii institut geologii Arktiki. Informatsionnyi biulleten' [Scientific Research Institute of Arctic Geology. Information Bulletin]. no. 14, 1959.

Symposium on salts of marine origin, held in the German Democratic Republic in 1958. N. S. Spiro. p. 7-8.
Finds of Mesozoic sediments in the northern Siberian Platform in the upper Bolshaya Romanikha Valley. V. P. Safronov. p. 9-13.
Age of marine Paleozoic series in the Noril'sk region. L. D. Miroshnikov, A. G. Kravtsov. p. 14-19
Some data on the results of studies of Paleozoic sediments on the left bank of the lower Lena Valley. T. M. Emel'iantsev, A. I. Kravtsova. p. 19-24.
Mineralogical studies of sulfide copper-nickel deposits. E. N. Eliseev. p. 25-28.
Ilmenorutile from carbonatites in the northern Siberian Platform. M. I. Tuchkova. p. 28-29.
Age of alkali-ultrabasic rocks in the Maymecha-Kotuy region based on the studies of their residual magnetism. B. V. Gusev. p. 30-33.
Method of prospecting for original deposits of diamonds. A. I. Shalimov. p. 33-40.
Basic geological characteristics of the northwestern slopes of the central

Koryak Range. B. Kh. Egiazarov. p. 41-50.

New data on the geology of the northern Verkhoyansk Range. V. M. Lazurkin. p. 50-58.

Studying the evolution of the composition of ocean waters. N.S. Spiro. p. 59-67.

Izv. AN Arm. SSR. khim nauki.
Akademiia nauk Armianskoi SSR, Erivan. Izvestiia. Khimicheskie nauki [Academy of Sciences of the Armenian S. S. R. Bulletin. Chemical Sciences]. vol. 12, no. 6, 1959.

Thermal reduction of magnesium by carbides. Report No. 2: Thermal reduction of dolomite by calcium carbide. M. V. Darbinian. p. 389-405.

Izv. Kom. po fiz. plan.
Akademiia nauk SSSR. Komissiia po fizike planet. Izvestiia [Academy of Sciences of the U. S. S. R. Committee on the Physics of Planets. Bulletin]. no. 1, 1959.

Rocks which most correspond to those forming the lunar surface. N. P. Barabashov, A. T. Chekirda. p. 5-39.

Probable dimensions of the unevenness of microrelief on the moon's surface. N. N. Sytinskaia. p. 81-84.

Degree of the evenness of continents and seas on Mars. I. K. Koval'. p. 85-92.

Thermal development of asteroids. S. V. Maeva. p. 105-108.

Izv. vys. ucheb. zav.; geol. i razv.
Russia (1923- U. S. S. R.) Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia. Izvestiia vysshikh uchebnykh zavedenii; geologiia i razvedka [Ministry of Higher and Secondary Specialized Education. Bulletin of the Institutions of Higher Learning; Geology and Prospecting]. vol. 3, no. 4, April 1960.

Precambrian in Bet-Pak-Dala and adjacent regions in Kazakhstan. N. G. Markova. p. 3-25.

Relationship between the hydrothermal mineralization in the Buluktay deposit and lamprophyre dikes (western Transbaikalia). G. I. Tugovik. p. 58-65.

Some evidence of boudinages in Olovyannaya District (eastern Transbaikalia). V. G. Gladkov. p. 66-71.

Geochemistry of diabases and tufas in the central Vilyuy Valley. I. F. Lobanov. p. 72-74.

Ilmenite-magnetite ores in the Arsent'yevo deposit and mineral formation in them. A. I. Perelygina, S. M. Smirnov. p. 75-85.

Evidence of manganese ores in Gornaya Shoriya. S. S. Il'enok, P. G. Usov. p. 86-88.

Characteristics of the distribution of fluorite deposits in the southern part of eastern Transbaikalia. P. A. Strona. p. 89-92.

Change in the quantity of carbonates, iron sulfides, and other components in combustible shales in supergene processes. I. K. Illarionov. p. 93-102.

Hydrogeochemistry, its problems and methods. A. M. Ovchinnikov, V. V. Krasintseva. p. 103-111.

Izv. vys. ucheb. zav.; gor. zhur.
Russia (1923- U. S. S. R.) Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia. Izvestiia vysshikh uchebnykh zavedenii; gornyi zhurnal. [Ministry of Higher and Secondary Specialized Education. Bulletin of the Institutions of Higher Learning; Mining Journal]. no. 7, 1960.

Leakage through edges of gas barriers. I. I. Vakhrameev. p. 59-67.

Splitting of coal and rock by tearing away A. F. Kichigin, A. D. Saltanov, V. D. IArema. p. 75-81.

Calculating the interaction between wheels and peat deposits. M. M. Tanklevskii. p. 82-86.

Izv. vys. ucheb. zav.; neft' i gaz
Russia (1923- U. S. S. R.) Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia. Izvestiia vysshikh uchebnykh zavedenii; neft' i gaz [Ministry of Higher and Secondary Specialized Education. Bulletin of the Institutions of Higher Learning; Petroleum and Gas]. vol. 3, no. 6, 1960.

Prospects for finding oil and gas in the Balkhas-Khunuk uplift in southern Daghestan. V. L. Galin. p. 3-8.

Study of structural characteristics of the interstitial space based on electric logging data. L. A. Buriakovskii. p. 9-16.

Mineral, geochemical, and other characteristics of the Maykop series in Azerbaijan from the point of view of its oil forming properties. A. G. Seidov, G. I. Teodorovich. p. 25-30.

Petroleum in Ul'yanovsk Province. p. 38

From Devonian depths. p. 38.

Hardness of well bottom rocks. V. S. Fedorov, I. S. Finogenov. p. 51-55.

Oil and gas prospects in the United Arab Republic. P. P. Zabarinskii. p. 88, 122.

Determining the function of pressure in layers of petroleum fields of uneven permeability. A. G. Tukaev. p. 111-118.

From the history of the development of studies on oil shales in Russia. K. V. Kostrin. p. 137-142.

auka i zhizn' [Science and Life].
vol. 27, no. 6, June 1960.

Earth's hot breath. I. N. Dvorov. p. 17-22.
Bolshaya Khadata Station.
D. IU. Venieri. p. 56-59.
Television in geology. M. Krajčik. p. 72.
Is there such a thing as continental drift?
E. A. Nefed'eva. p. 78-79.

auka i zhyttia [Science and Life]. In Ukrainian.
vol. 10, no. 7, July 1960.

Are the deserts advancing toward our steppes? I. O. Buchyns'kyi. p. 34-36.
Terrestrial magnetism and the magnetic fields of cosmic bodies.
V. I. Ivanchuk. p. 46-50.

eft. Khoz.
Neftianoe khoziaistvo [The Petroleum Industry]. vol. 38, no. 1, January 1960.

Petroleum and gas industries in Kuybyshev Province in 1960. V. I. Muravlenko. p. 17-21.
Petroleum industry in the Chechen-Ingush A. S. S. R. M. A. Evseenko. p. 22-27.
Progress of the petroleum industry in the Ukraine. V. M. Baevich, R. D. Faniev. p. 27-30.
Determining certain parameters of reservoir rocks by drill-stem testing (to be concluded). IU. P. Borisov, E. D. Mukharskii. p. 56-59.

sn., fund. i mekh. grun.
Osnovaniia, fundamenty i mekhanika gruntov [Foundations and Soil Mechanics].

Vol. 2, no. 3, 1960.
Filtration capacity and deformations due to loads and to the lowering of the water table in loess and loesslike soils in the southeastern part of the Ukraine. I. N. Kruglov. p. 10-12.
Investigating the height of capillary rise in loess soils. V. A. Smirnov, p. 12-13.
Selecting wrong methods for building on permafrost. V. F. Zhukov, A. N. Tolstov. p. 27-28.

Vol. 2, no. 4, 1960.
Moisture in clayey soils as one of the factors of their bearing capacity. E. T. Penfilov. p. 13-14.
Calculating maximum temperatures of house foundations with basements built in permafrost. S. V. Tomirdiaro. p. 15-18.
Lateral pressure in loess soils. A. A. Grigorian. p. 20-21.
Consolidating foundations with thermo-karst cavities. D. V. IAtsenko. p. 27-28.

iroda [Nature]
Vol. 49, no. 7, July 1960.
External radiation belt of the earth. S. A. Slavatinskii. p. 3-6.
Sun and ice; new methods to accelerate melting. I. S. Peschanskii. p. 49-54.
Kaalijärv craters. E. L. Krinov. p. 55-60.
Geological history of the Pyrenees. p. 60.
Relief and vegetation of Ko Mountain. N. G. Vasil'ev. G. E. Kurentsova. p. 90-92.
On the floor of the Romanche trench. A. N. Kosarev. p. 106-107.
Stone mushrooms. E. IA. Marchenko. p. 113-114.

Probl. geokhim.
Problemy geokhimii [Problems of Geochemistry] no. 1, 1959.

From the editor. p. 3-5
Geochemistry of principal sulfide copper-zinc deposits in the U. S. S. R. [with summary in English, pp. 301-309]. E. N. Eliseev. p. 6-183.
Primary dispersion halos of complex metal deposits in the Rudnyy Altai [with summary in English, p. 309]. D. I. Gorzhevskii, G. I. Rossman. p. 184-189.
Geochemical characteristics of the distribution of chemical elements in copper-zinc deposits of the Central Urals [with summary of English, pp. 309-311]. E. K. Lazarenko. p. 190-217.
Principles for mineralogical classification of complex sulfide ores for industrial purposes [with summary in English, p. 311]. E. K. Lazarenko, B. V. Merlich. p. 218-227.
Geochemistry of underground waters in mineral deposits of the Western Ukraine [with summary in English, p. 311]. G. A. Goleva. p. 228-248.
Genetic relationship between mercury and lead-zinc ores in Transcaucasia [with summary in English, p. 312]. B. V. Merlich. p. 249-255.
Radioactivity of bituminous rocks of the menilite series [with summary in English, p. 312]. M. P. Gabinet. p. 256-260.
Rare and trace elements in tourmalines [with summary in English, p. 312-313]. M. M. Slivko. p. 261-271.
Geochemistry of tellurium in Transcarpathian altered rocks [with summary in English, p. 313]. E. Lazarenko. p. 272-279.
Role of colloids in the formation of quartz in pyrite deposits of the Central Urals [with summary in English, p. 313]. IU. A. Dolgov. p. 280-295.
Find of hauerite in the Rozdol native sulfur deposit [with summary in English, p. 314]. V. I. Srebrodol'skii, L. D. Arkhipova, G. V. Kuznetsov. p. 296-300.

Sil'. bud.
Sil's'ke budivnytstvo [Rural Construction]. In Ukrainian. vol. 10, no. 4, April 1960.

The Department of Geological prospecting

and Technical Assistance has started its work. p. 23.

Sovetskoe foto [The Soviet Photograph]. vol. 20, no. 2, February 1960.

Among rocks and sands. D. Shcherbakov. p. 30-31.

Trudy Alt. GMNII
Akademiia nauk Kazakhskoi SSR, Alma-Ata. Altaiskii gornometallurgicheskii nauchno-issledovatel'skii institut. Trudy. [Academy of Sciences of the Kazakh S. S. R. Altai Scientific Research Institute of Mining and Metallurgy. Transactions]. vol. 8, 1960.

Foreword. p. 3-9.
Position of the Rudnyy Altai in the system of tectonic zones of the southwestern Altai, based on geological and geophysical data. P. F. Ivankin. p. 10-31.
Relationship between volcanic and sedimentary facies in the northwestern part of the Irtysh shear zone. N. I. Stuchevskii. p. 32-43.
Systematics and petrochemistry of igneous complexes in the southwestern Altai. P. F. Ivankin, P. G. Vedernikov. p. 44-69.
Metallogenetic stages and genetic types of the endogenous mineralization in the Rudnyy Altai. P. F. Ivankin, P. V. Inshin. p. 70-83.
Contact changes as indications in ore prospecting as exemplified by the exploratory work in the Irtysh Valley portion of the Altai ore region. P. F. Ivankin, V. S. Kuzebnyi, P. V. Inshin. p. 84-93.
Geology of the Zavodinskoye ore deposit. P. V. Inshin. p. 94-109.
Relationship between small intrusions and sulfide deposits in the Berezovskiy-Belousovskiy ore region. P. G. Vedernikov. p. 110-125.
Relationship between the hydrothermal metamorphism and sulfide mineralization in the Berezovskiy-Belousovskiy ore region. IU. IU. Vorob'ev and others. p. 126-145.
Types of ores and stages in the ore formation in the Novoberezovskoye deposit. P. F. Ivankin. N. M. Mitriaeva, Z. A. Purkina. p. 146-169.
Internal structure of the ore-bearing zone in the Irtysh deposit. IU. IU. Vorob'ev. p. 170-182.
Hydrothermal changes in rocks of the Zavodinskoye ore deposit. P. V. Inshin, V. M. Inshina. p. 183-204.
Stratigraphy of the northwestern Irtysh shear zone. N. I. Stuchevskii. p. 205-211.
Zonal potassic feldspar-epidote-sulfide rapakivi textures in propylites. V. M. Inshina. p. 212-215.
Structure and ore potential of the northeastern shear zone. Z. M. Nurbaev, D. N. Gadzhi. p. 216-219.

Trudy DVFAN SSSR. Ser. geol.
Akademiia nauk SSSR. Dal'nevostochnyi filial, Vladivostok. Trudy. Seriiia geologicheskaia [Academy of Sciences of the U. S. S. R. Far Eastern Branch. Transactions. Geological Series], vol. 4, 1960.

Geotectonic divisions of the southern part of Khabarovsk Territory and Sakhalin and Amur Provinces. V. V. Onikhimovskii. p. 3-52.
Geology and mineralogy of the Pervyy Sovetskiy Rudnik deposit (Tetyukhe Valley). L. N. Khetchikov. p. 53-167.

Trudy GGI
Leningrad. Gosudarstvennyi gidrologicheskii institute. Trudy [State Hydrological Institute. Transactions] no. 74, 1960.

Structure of large-scale pulsations in open streams. V. M. Makkaveev. p. 3-21.
Morphological study of rivers as a basis for solving problems associated with the utilization of bottom lands for agricultural purposes. I. V. Popov. p. 22-54.
Laboratory determination of the resistance of rocks to the action of waves. O. G. Grigor'eva. p. 71-88.

Trudy GOIN.
Moscow. Gosudarstvennyi okeanograficheskii institut. Trudy [State Oceanographical Institute. Transactions]. no. 49, 1960.

Possible distribution of water discharge in arms of the eastern part of the Volga Delta in connection with the construction of hydraulic works. S. S. Baidin, p. 7-18.
Regularities of the change of stream velocity and discharge in the steep-to-shore region near river estuaries and associated processes based on studies of the Kuban River. A. I. Simonov. p. 19-37.
Calculation of spatial distribution of water salanity in shore waters near river estuaries based on estuary studies of the Volga River. L. S. Borishanskii. p. 38-46.
Level variations in the lower course of the Dnieper River due to flow and rise processes. M. N. Kostianitsyn. p. 47-60.
Some features of the level regimen in the estuary region of the Terek River. I. P. Beliaev. p. 61-78.
Unusual rise of water in the estuary of the Northern Dvina River. A. IA. Popov-Vvedenskii. p. 79-85.

Some characteristic of the ice regimen in the shore area near the estuary of the Volga River. N. A. Skriptunov. p. 86-97.
Some characteristics of river bed evolution near the seashore. V. N. Mikhailov. p. 98-110.
Some general structural characteristics of the Don Delta. V. V. Romashin. p. 111-117.
Hydrological characteristics of estuary regions of the Neman and Pregel rivers. L. L. Markova, I. IA. Nechai. p. 118-188.

rudy Gidroproekta.
Moscow. Vsesoiuznyi proektno-izyskatel'skii i nauchnoissledovatel'skii institut "Gidroproekt" imeni S. IA. Zhuk. Trudy. [All-Union Planning and Research Institute "Gidroproekt," named after S. IA. Zhuk. Transactions]. vol. 2, 1959.

Use of rigid models in studying deformations of river channels. A. D. Khalturin, I. A. Kuz'min. p. 37-56.
Method of seepage calculations in designing earth dams. A. P. Voshchinin. p. 57-77.
Calculating the stability and strength of earth foundations of hydraulic structures. I. N. Shcherbiana. p. 137-167.
In situ investigation of the work of the anchored upstream floor of the Volga Hydroelectric Power Station. I. IA. Grodzenskaia, A. I. TSarev. p. 168-176.

rudy IGEM
Akademiia nauk SSSR. Institut geologii rudnykh mestorozhdenii, petrografii, mineralogii i geokhimii. Trudy [Academy of Sciences of the U.S.S.R. Institute of the Geology of Ore Deposits, Petrology, Mineralogy, and Geochemistry. Transactions]. no. 27, 1960.

Contact effect of alaskite granites of the Kurama Range (Central Asia) on the surrounding granodiorites and effusive rocks. I. S. Smorchkov, B. I. Omel'ianenko. p. 7-26.
Contact interaction and assimilation processes in intrusive rocks on the northern slope of the Chatkal Range (Central Asia). I. M. Volovikova. p. 27-38.
Role of assimilation and contamination processes in the formation of the Khodzhaachkan alkaline massif (Central Asia). B. I. Omel'ianenko. p. 39-55.
Hybrid rocks in the basin of the Gava River on the southern slope of the Kurama Range (Central Asia). G. A. Lisitsina. p. 56-65.
Some characteristics of accessory minerals occurring in granites of the Charkasar massif (southern slope of the Kurama Range, Central Asia). G. A. Lisitsina. p. 66-77.
Quartz porphyries of Samgar as an example of conjugate intrusions and effusions. O. P. Eliseeva. p. 78-91.
Crystallization order of accessory minerals as exemplified in some igneous rocks of the Kurama and Chatkal Ranges (Central Asia). O. P. Eliseeva. p. 92-105.
Characteristics of trace element distribution in intrusive rocks on the southwestern slope of the Chatkal Range (Central Asia). P. S. Kozlova. p. 125-138.
Characteristics of the distribution of accessory minerals in upper Permian intrusive rocks on the southwestern slope of the Chatkal Range (Central Asia). P. S. Kozlova. p. 125-138.
Hybrid rocks of Ken'-Shiy (Kazakhstan, northwestern part of the Balkhash region). O. S. Polkvoi. p. 139-147.
Interrelationships of granitoids of the Karkaralinsk intrusion in central Kazakhstan. N. F. Anikeeva. p. 148-159.
Petrography of vein granites in Devonian intrusions of Bet-Pak-Dala (Kazakhstan). S. V. Efremova. p. 160-180.
Geological interrelationships of igneous rocks near the village of Nizhnyaya Teberda (Northern Caucasus). V. V. Ploshko. p. 181-209.
Geological and petrographical survey of magmatic rocks in the Pshish-Tuapsinka interfluve, northwestern Caucasus. A. M. Borsuk. p. 210-228.

Trudy VNIGNI
Moscow. Vsesoiuznyi nauchno-issledovatel'skii geologorazvedochnyi neftianoi institut. Trudy [All-Union Scientific Research Institute of Petroleum Geology and Prospecting. Transactions]. no. 25, 1959.

Basic geological characteristics of the northern part of the Volga-Ural region. L. M. Birina. p. 3-117.
Permian stratigraphy and paleogeography of the northern part of the Volga-Ural region. Z. I. Borozdina. p. 118-200.
Stratigraphy and lithology of Devonian and lower Carboniferous sediments as revealed as R-1 and R-2 wells drilled in the Shikhovo-Shepets uplift. L. M. Birina. p. 201-223.

Trudy VNIGRI
Leningrad. Vsesoiuznyi neftianoi nauchno-issledovatel'skii geologo-razvedochnyi institut. Trudy. [All-Union Petroleum Geological Prospecting Institute. Transactions]. no. 153, 1960.

Stratigraphy of Oligocene and Miocene de-

posits of Ciscarpathia based on the study of foraminifers. N. N. Subbotina, L. S. Pishvanova, L. V. Ivanova. p. 5-155.
Microfauna of Oligocene and Miocene deposits of the Vorotyshche River (Ciscarpathia). N. N. Subbotina. p. 157-263.
The genus Buccella andersen and its species from the Neogene of Sakhalin. N. A. Voloshinova. p. 265-305.
Radiolarians of the middle and upper Miocene of northern Sakhalin. G. E. Kozlova. p. 307-325.
Stereoscopic photomicrography of foraminifers. V. V. Krivoborskii. p. 327-339.

TSir. Astron. obser. Khar. un.
Kharkov. [Universitet. Astronomicheskaia Observatoriia. TSirkuliar [University Astronomical Observatory. Circular]. no. 21, 1960.

Structure of surface layers on the moon and Mars. N. P. Barabashov, V. I. Garazha. p. 3-18.

Uch. zap. LGU.
Leningrad. Universitet. Uchenye zapiski [University. Scientific Records]. no. 291, 1960.

Feldspars from alkaline pegmatites of the Il'menskiye Mountains. L. L. Solodovnikova. p. 3-63.
Peridotites from the basin of the Uls River (Northern Urals) and their relation to the kimberlite group. IU. D. Smirnov, A. A. Kukharenko. p. 64-90.
Alkaline gabbroid intrusions in the northwestern spurs of the Talas Ala-Tau. M. P. Orlova. p. 91-121.
The granitic intrusion of Airtau (central Kazakhstan). M. I. Burakov. p. 122-150.
Microchemical analysis of lead minerals. T. N. Burakova. p. 151-172.
Cases of alkaline metasomatism in gneisses of the eastern part of the central watershed of the Kola Peninsula (Keyv Range). L. IA. Kharitonov. p. 179-201.

Ukr. bot. zhur.
Ukrains'kyi botanichnyi zhurnal [Ukrainian Botanical Journal]. In Ukrainian. vol. 17, no. 3, 1960.

History of the development of vegetation in the left-bank area of the Ukrainian forest steppe during the last glacial and postglacial periods [with summary in English]. O. T. Artiushenko. p. 48-65.

Vest. AN Kazakh. SSR
Akademiia nauk Kazakhskoi SSR, Almat-Ata. Vestnik [Academy of Sciences of the Kazakh S. S. R. Journal].

Vol. 16, no. 5, May 1960.
Methods involved in compiling a hydrogeological map of Kazakhstan. U. M. Akhmedsafin. p. 27-32.
Discovery of the lower Paleolithic in Kazakhstan. Kh. Alpysbaev. p. 59-61.
Old Russian names of minerals. Report no. 1, A. G. Medoev. p. 80-84.
Discovery of fossil Quaternary flora in the Tien Shan. V. S. Kornilova. p. 89-90.

Vol. 16, no. t, June 1960.
Mountain formations on the earth and their causes. S. S. Nikolaev. p. 23-33.
Age of nodular ores of the Sokolovka deposit. V. F. Bobkov, E. D. Shlygin. p. 68-70.
Structure of one of the salt domes of the Caspian Sea Region. S. A. Dolgikh. p. 71-75.
Geochemical methods in exploring for copper pyrite ore formations. M. A. Glazovskaia, K. M. Mukanov. p. 78-79.
Finds of upper Triassic flora in the Ketmen Range. E. R. Orlovskaia. p. 82-83.

Vest. AN SSSR.
Academiia nauk SSSR. Vestnik [Academy of Sciences of the U. S. S. R. Journal]. vol. 30, no. 7, July 1960.

Geophysical research using rockets and and artificial satellites. A. A. Blagonravov, M. G. Kroshkin. p. 7-20.
Joint work of Soviet and Korean geologists. L. N. Khetchikov, Khan Don Sik. p. 64-66.
Final meeting of the editorial board for the first international tectonic map of Europe. A. A. Bogdanov. p. 86.
Use of radioactive isotopes and radiation in searching for mineral and coal deposits. p. 88-89.
Studying the main features of the location of minerals. G. D. Kurochkin. p. 93-94.
Problems in geomorphological research. IU. A. Meshcheriakov. p. 94-95.
Further problems in the exploitation of the Kursk Magnetic Anomaly. N. N. Afendikov. p. 104-105.

VOP. geog.
Voprosy geografii [Problems of Geography]. no. 48, 1960.

Division of the ocean into biogeographical regions. V. G. Bogorov. p. 71-89.
Development of erosion gullies in natural zones of the U. S. S. R. B. F. Kosov. p. 256-274.

Zhur. anal. khim.
Zhurnal analiticheskoi khimii [Journal of Analytical Chemistry]. vol. 15, no. 2, March-April, 1960.

olating rare earth elements from minerals [with summary in English]. F. V. Zaikovskii, V. S. Bashmakova. p. 166-169.

apid methods for the spectrum analysis of rare elements; Report No. 1: Analysis of complex mixtures of rare earths [with summary in English]. V. A. Korneev. p. 170-174.

Photometric determination of thorium in monazites with arsenazo II [with summary in English]. V. I. Kuznetsov, S. B. Savvin. p. 175-179.

RECENT TRANSLATIONS IN GEOLOGY

Those who follow foreign scientific literature should make a point of looking up NLL Translations, formerly the LLU Translations Bulletin. This British counterpart of the Department of Commerce's Technical Translations changes its name with the January 1961 issue (vol. 3, no. 1), reflecting a change in title of its parent institution from Lending Library Unit to National Lending Library for Science and Technology. With the change in name comes a change in format to include survey-type articles and translations.

Of particular interest to geologists is "The Present State of Petroleum Chemistry and Technology in China", on page 79 of the February issue (vol. 3, no. 2), translated from Chzhan Da-yui [Institute of Petroleum of the Academy of Sciences of the Chinese People's Republic], previously appearing in the Russian journal, Khimiya i tekhnologiya topliva i masel, 1960, no. 4, pp. 66-69. The front section of each issue of NLL-Translations also includes capsule reports by western scientists of Soviet conferences and visits to Soviet installations.

Publication of NLL Translations is part of the broad scientific encouragement program of the Department of Scientific and Industrial Research, whose program is of a slightly different scope from that of our National Science Foundation. As a D. S. I. R. official phrased it, "It happens, owing to the different responsibilities of the National Science Foundation and the D. S. I. R., that one can regard American cover-to-cover translations as dealing primarily with pure science whilst the British translations are more concerned with technology. This means that the United Kingdom is primarily responsible for journals in the engineering field, a field in which the Russians excel and, incidentally, one in which there is a dearth of high grade Western language literature."

D. S. I. R. aims to publish the translations within two or three months of receipt of the Russian originals.

Inquiries regarding single or serial translations should be addressed to the D. S. I. R. Lending Library Unit, 20 Chester Terrace, London N. W. 1. Free lists of cover-to-cover translations of periodicals, irregular serials, and books from Russia and current periodicals from China are available on request. Subscription or single copy orders for NLL Translations should be addressed to Her Majesty's Printing Office, P. O. Box 569, London S. E. 1, England.

The current list of Recent Translations in Geology includes items from the first three issues of NLL Translations (vol. 3, nos. 1, 2, and 3).

Other sources for the current list are:

Associated Technical Services, Bulletins nos. 3W and 2M.

Columbia Technical Translations, Tables of Contents, Bulletin (Izvestiya), AN SSSR, physics series, v. 23, nos. 2, 3 and 7.

Technical Translations, v. 5, no. 2.

Translations under the PL-480 Program, List no. 4 (final list; henceforth, all listings will be made initially in Technical Translations).

Not included in the subsequent list are items occurring in the following Soviet journals, which are translated cover-to-cover and generally contain articles of interest to geologists:

Atomic Energy, published by Consultants Bureau.

Bulletin (Izvestiya) of the Academy of Sciences U. S. S. R., Geophysics Series, published by the American Geophysical Union.

Doklady of the Academy of Sciences of the U. S. S. R., Earth Sciences Sections, (Geochemistry, geology, geophysics, hydrogeology, mineralogy, paleontology, petrography, lithology and permafrost), published by the American Geological Institute.

Geochemistry, published by the Geochemical Society.

Geodesy and Cartography, published by the American Geophysical Union.

Izvestiya of the Academy of Sciences of the U. S. S. R., Geologic Series, published by the American Geological Institute.

Petroleum Geology, published by the Review of Russian Geology.

Problems of the North, published by the National Research Council of Canada.

Soil Science, published by the American Institute of Biological Sciences.

Soviet Geography, selected translations and reviews published by the American Geographic Society.

Soviet Physics: Crystallography, published by

the American Institute of Physics.

Geologists and translators are invited to bmit titles which have not been cited by ser-ces from which we compile these lists. The bmittal of a copy of the translation itself will construed as an offer for IGR to publish, ake copies available at cost of reproduction d/or consign it to a major translations re-sitory at our discretion. Suggestions for proving this service are welcome.

For full names and address of sources cited initials see IGR v. 3, no. 1, pp. 88-89, d no. 3, p. 270.

RECENT TRANSLATIONS

kudimova, E. V., and Petrashen', V. I., 1955, Determination of Mb in a mineral concentrate: Tr. novocherkassk politekh. in-ta, v. 31, pp. 73-77. NLL (LLU), RTS 1709. 12 s. 6 d. (Approx. $1.50).

onymous, no date, Biulleten' Moskovskogo obshchestva ispytatelei, Otdel geologicheskii: v. 31, nos. 1, 2, 3 and 4, 475 pp. PL-480, OTS 61-11402-1, 61-11402-2, 61-11402-3, and 61-11402-4.

onymous, 1957, A method to determine germanium in ores: Giredment, Moscow (in German). GE-1, 133. (no price listed).

onymous, 1960, Information on Soviet bloc International Geophysical Cooperation, nov. 4-Dec. 2. OTS-PB 131 632-T (143-147). $12.00 series.

syuk, G. A., Markov, K. K., and Shumskii, P. A., 1956, Geographical observations in an antarctic "oasis": Izv. vses. geograf. obshch., v. 4, no. 88, pp. 316-350. PL-480, OTS 60-21825. $0.50

rkovskaya, M. G., 1959, The distribution of fragmented material in the beach areas of the Black Sea: Vestnik, Leningr. un-ta, ser. geol. i. geograf. v. 4, no. 4, pp. 11-35. NLL (LLU), RTS 1561. 60s, (approx. $8.50).

rrois, C., 1904, Spirorbis of the Carboniferous of Bruay: Ann. soc. geol. Nord (Lille), v. 33, pp. 50-63. ATS, 96-FJ. $12.00.

lluigi, A., 1955, Direct geoelectric prospecting for petroleum: Geofisc. e meteor., v. 3, no. 1-2, pp. 23-29. ATS, 125-IJ. $17.65.

__________, 1955, The "Elflex" geoelectric method for the direct search for oil: Boll. del serv. geol. d'Italia, v. 77, no. 1, pp. 131-66. ATS, 126-IJ. $27.55.

lyayevskiy, N. A., Vakhrameyev, I. I., et al., 1960, Results of the All-China Stratigraphic Conference, Peking, Nov. 13-21: Sovetskaya Geologiya (U.S.S.R.), no. 2, pp. 149-160, JPRS 5306; ord. OTS 60-41172. $0.75.

Bendegom, L. van: See van Bendegom, L.

Berthois, L., 1947, The Redonian sands of Apigne (Ille-et-Vilaine) and the fluvial sands that overlay them: Bull. soc. geol. France, v. 16, no. 5, pp. 133-145. ATS, 103-FJ. $8.50.

Blumer, M., 1950, Geochemical investigations. Part 4, The Limits of existence of inorganic ions in the formation of sedimentary rocks: Helv. chim. acta. v. 33, no. 6, pp. 1568-1581. ATS, 109 GJ. $12.95.

Blyumen, L. M., 1943, Common salt as a catalyst in silicate-forming reactions in the solid phase: Zh. prikl. khim., no. 16, p. 81. NLL (LLU) M. 1225.

Bogomolov, A. I., 1954, Primary bituminous substances in the series of transformations of organic remains into petroleum: Zhur. priklad. khim., v. 27, pp. 1012-1016. ATS, RJ-243. $7.95.

Caillère, S., and S. Hênin, 1955, Chemical study of phyllites of sedimentary iron ores: Bull. du Groupe Fr. des Argiles, v. 6, no. 1, pp. 23-29. ATS, 107-FJ. $7.25.

Carozzi, A., 1948, A contribution to the study of fluvial sands. The case of symmetrically meandering streams: Arch. sci. (Geneva), v. 1, pp. 195-199. ATS, 104-Fj. $4.55.

Correns, C. W., no date, Scientific results of the German Atlantic expedition on the exploration and survey ship "Meteor" 1925-1927. Excerpt of v. 3, part 3, The sediments of the equatorial Atlantic Ocean, Section D., pp. 278-298. ATS, 108-GJ. $23.90.

Dangeard, L., 1930, Enveloping foraminifera of oölites and pisolites: Bull. soc. gèol. France, v. 4, no. 30, pp. 173-190. ATS-87-FJ. $10.50.

Derville, P. H., 1935, Observations and considerations concerning the genus Nubecularia: Bull. gèol. soc. Franc, v. 5, no. 5, pp. 621-628. ATS, 91-FJ. $9.75.

Derville, H., 1936. Description of the algae in nubecularian limestones: Bull. soc. gèol. France, v. 6, no. 5, pp. 487-493. ATS, 80-FJ. $9.45.

__________, 1937, Some observed details concerning the reef forms of Nubecularia: Bull. soc. gèol. France, v. 7, no. 5, pp. 632-635. ATS, 88-FJ. $5.95.

Dokuchaev, V. V., 1958, The application of drainage in the reclamation of salinized soils (collection of articles): Moscow, 228 pp. PL-480, OTS 60-51191. $2.50.

Dolcetta, A., 1949, Experimental apparatus

for the solution of hydrodynamic problems with the aid of the method of electrical analogy: L'Energ. elettrica v. 26, pp. 461-468. ATS, 134-IJ. $15.50.

Dostalek, M., 1954, Propane-oxidizing bacteria: Českoslov. biol., v. 3, no. 3, pp. 173-181. ATS, RJ-288. $14.60.

Ekzertsev, V. A. and S. I. Kuznetsov, 1954, Investigations of the microflora of the oil fields of the second Baku: Mikrobiol., v. 23, pp. 3-14. ATS, RJ-191. $19.20.

Engelhardt, W. von: See von Engelhardt, W.

Fenner, R., 1938, Investigations of rock pressure: Gluckauf Berg- u. Hüttenmän. Z. v. 74, no. 32, pp. 681-695. ATS, 117-GJ. $35.75.

Fester, C., 1952, Contribution to the knowledge of asphaltites [Peru and Argentina]: Erdöl u. kohle, v. 5, no. 6, pp. 337-341. ATS, 115-GJ. $10.95.

Flaschka, H., and Huditz, F., 1952 [1953], Rapid determination of Ca in magnesites: Radex-rundchau (Austria), 1952, no. 4, pp. 181-186. SLA 60-18861. $1.80 mi or ph.

Gillet, S., and H. Derville, 1931, New reef bed of Nubecularia at Gricov, near Kishinev [Chisinau] (Bessarabia), from: Petrographic study, pp. 728-733; Bull. geol. soc. France, v. 1, no. 5, pp. 721-738. ATS, 90-FJ. $12.95.

Glogoczowski, J. J., and K. Szpulowa, 1952, Hydrochemical prospecting for petroleum deposits: Nafta (Poland), v. 8, no. 6, pp. 145-147. ATS, RJ-172. $4.90.

Gortikov, V. M., and L. I. Panteleeva, 1937, Kinetics of solvation of calcium carbonate: Zhur. Obshch. khim., v. 7, pp. 58-64. ATS, RJ-140. $8.70.

Hantzschel, W., 1938, Structure and formation of sand waves in shallow seas: Senckenbergiana, v. 20, no. 1-2, pp. 1-42. ATS, 128-GJ. $25.75.

Huera, A. E., 1955, Gravimetric and seismic exploration in recifal structures of the golden lane type: Bol. asoc. mex. geol. petrol., v. 7, no. 7-8, pp. 241-311. ATS, 136-SP. $30.75.

Ivanov, N. P., Spectroscopic determination of U by the method of isotopic doping: Izv. AN SSSR, ser. fiz., v. 23, no. 7, pp. 1148-1149. CTT. $8.00.

Izokh, Ye. P., Kolmak, L. M., et al., 1960, Late Mesozoic intrusions of the central Sikhote-Aline and the mineralization related to them (conclusion): partial translation, unidentified article, pp. 213-215. LC or SLA 60-23744. $1.80 mi or ph.

Kalinin, N. K., and P. Ya. Polubarinova-Kochina, 1947, Unsteady motion of ground waters with a free surface: Priklad. mate. i. mekhan., v. 11, pp. 231-236. ATS, RJ-197. $5.40.

Karrer, F., and J. Sinzow, 1876, Occurrence of the foraminer genus Nubecularia in the Sarmatian sands of Kishinev: Sitzber. math. naturw. Kl. kaiser, Akad. Wiss. (Wien), v. 74, part 1, no. 1-5, pp. 272-284. ATS, 92-GJ. $10.95.

Khalevin, N. I., 1960, Measurement of rock porosity by sonic well logging: Razved. i. promysl. geofiz. (U.S.S.R.), v. 30, pp. 3-9. ATS-37M45R. $8.50.

Klibashev, K. P., 1960, The session of the scientific council of the State Hydrological Institute on the results of scientific research works in 1959: Meteor. i. gidro. (U.S.S.R.), no. 5, pp. 65-66. OTS 61-11082. $0.50.

Knetsch, G., 1950, Observations in the Libyan Sahara: Geol. Rundschau, v. 38, no. 1, pp. 40-59. ATS, 106-GJ. $19.95.

Korol'kov, I. I., and A. V. Krupnova, 1953, Transformation of aqueous modifications of calcium sulfate: Zhur. priklad. khim., v. 26, pp. 907-911. ATS, RJ-213. $9.20.

Krejci-Graf, K., 1955, The geochemistry of petroleum formation: Erdöl u. kohle, v. 8, no. 6, pp. 393-401. ATS, 110-GJ. $18.50.

Kukharenko, A. A., 1958, The Paleozoic complex of ultrabasic and alkali rocks in the Kola peninsula and the related deposits of the rare metals: Zap. vses. mineral. obshch., v. 87, no. 83, pp. 304-314. NLL(LLU), RTS 1662. 27 s 6 d. (approx. $3.50)

Langefors, U., et al., 1957, Damage from seismic vibrations due to blasting: Bobel hefte v. 23, pp. 220-239. ATS, 127-GJ. $22.75.

Lé Mehauté, B., 1957, The perviousness of of rock fill breakwaters to periodic gravity waves: La houille blanche, v. 12, no. 6, pp. 903-919. ATS, 136-FJ. $16.95.

Lifshits, I. M., and Obreimov, I. V., 1948, Some reflections on the twinning of calcite: Izv. AN SSSR, ser. fiz., v. 12, no. 2, pp. 65-80. NLL (LLU), M. 2636. Loan through authorized library.

Luchterowa, A., 1953, Prospecting for oil strata by the microbiological method: Nafta (Poland), no. 9, pp. 217-220. ATS, PJ-246. $13.30.

Lyast, I. Ts., 1960, On the relaxation polarization of crystals with the structure of rutile and perovskite: Tr. 2nd All-Union conf. on

physics of dieletrics. Izv. AN SSSR, ser. fiz. v. 24, no. 2, pp. 170-176. CCT. $8.00.

Millot, G., 1953, Transfer and neoformation in clay sedimentation: Comité intern. étude argiles, Compt. rend. 19e sess., Congr. géol. intern., Algiers, no. 18, pp. 163-175. ATS, 99-FJ. $14.95.

Morgante, S., and E. Milli, 1940, The sands of the Dacata and Errer rivers in Ethiopia: Giorn. geol. v. 14, pp. 17-38. ATS, 102-IJ. $15.35.

Nechaeva, N. B., 1955, Investigation of the process of methane formation by micro-organisms from the cores of gas- and petroleum-bearing strata of the second Baku: Mikrogiol., v. 24, no. 1, pp. 3-13. ATS, RJ-285. $21.60.

Nekrasov, I. Ya., 1960, A new type of beryllium mineralization: Geol. rudn. mestorozhd. no. 2, pp. 32-43 (in French). Fr-49, 2608 (no price listed).

Nikolayev, A. V., and Sorokina, A. A., 1951, Colorimetric determination of Li: Dokl. AN SSSR, v. 77, no. 3, pp. 427-428. LC or SLA 61-13590. $1.80 mi or ph.

Papp, A., 1955, Nubecularia from the Sarmatian stage of Wiesen (Burgenland): Burgenlandische Heimatblatter (Austria), v. 17, no. 2, pp. 49-55. ATS, 93-GJ. $8.25.

Pasch, B. R., 1952, The study of crater formation: Farbe und Lack (W. Germany), v. 58, no. 8, p. 356.

Pavlenko, L. I., 1960, Chemico-spectroscopic determination of Mb and W in igneous rocks: Izv. AN SSSR, v. 23, no. 7, ser. fiz., pp. 1144-1145. CTT. $8.00.

Petrova, Yu. N., and I. P. Karpova, 1954, Chemical composition of hydrocarbons in the dispersed organic matter of sedimentary rocks: Dokl. AN SSSR, v. 96, no. 2, pp. 331-334. ATS, RJ-289. $5.20.

Popov, M. A., 1956, Phase analysis of dolomitized gypseous rocks; Zavod. lab., v. 22, no. 2, pp. 157-160. ATS, RJ-529. $10.60.

Preobrazhenskii, I. A., 1955, Some shapes of zircon grains from granites of the Transbaikal region: Dokl. AN SSSR, v. 102, no. 1, pp. 145-147. ATS, RJ-481. $4.75.

Radchenko, O. A., and L. S. Sheshina, 1955, The genesis of porphyrins in crude oils: Dokl. AN SSSR, v. 105, no. 6, 1285-1286. ATS, RJ-480. $8.15.

Rauzer-Chernousova, D. M., and E. L. Kulik, 1949, The relationship between facies and fusulinids and the periodicity of their development: Izv. AN SSSR, ser. geol., no. 6, pp. 131-148. ATS, RJ-244. $28.00.

Reinhold, Th., 1948-49, The mechanism of sedimentation on tidal flats: Mededel. geol. sticht (N. S.), v. 3, pp. 75-80. ATS, 129-DU. $15.80.

Reshetina, T. S., 1960, Quantitative spectroscopic determination of the principal components of intrusive rocks: Izv. AN SSSR, ser. fiz. v. 23, no. 7, pp. 1143-1144. CTT. $8.00.

Rivière, A., and S. Vernhet, 1953, The influence of organic matter on the sedimentation of clays: Comité intern. étude argiles, Compt. rend. 19e sess., Congr. géol. intern., Algiers, no. 4, pp. 105-108. ATS, 100-FJ. $4.00.

Rivière, A., et al., 1955, Recent research on sedimentary clays: Bull. du groupe Fr. de Argiles, v. 6, no. 1, pp. 13-18. ATS, 101-FJ. $9.00.

Rode, A. A., 1955, The moisture properties of soils and underground strata: AN SSSR, Kiev, 117 pp. PL-480. OTS-60-51187. $1.25.

__________, 1957, Development of the science of soil water in the U. S. S. R.: Pochvovedenie, no. 10, pp. 1-15. PL-480, OTS 60-21141. $0.50.

Sapozhnikov, D. G., 1951, Recent sediments of geology of the Lake Balkhash: Deposition of carbonates in Lake Balkhash: Tr. AN SSSR, In-ta geol. nauk, no. 132, geol. ser. no. 53, pp. 158-171. LC or SLA 60-23750. mi $3.00 ph $6.30.

Schmid, C., 1958, Recent investigations of the problem of heavy-oil recovery from sand deposits. Part 1. Recovery by mining and flooding: Erdöl u. kohle v. 11, no. 1, pp. 6-11. ATS 122-GJ. $10.75. Part 2. Use of heat and solvents, v. 11, no. 2, pp. 72-75. ATS, 123-GJ. $8.55.

Schuster, O., 1952, The Varel channel of the Jade Bay (excerpts): Abhandl. senckenberg. naturforsch. Ges., no. 486, pp. 6-18, 26-38. ATS, 133-GJ. $37.95.

Selyutin, A. S., and N. A. Tikhomirov, 1957, High-intensity magnetic separator MS-2 for concentration of weakly magnetic ores and materials: unidentified Russ. mono., SLA and LC, 60-16528. $1.80. Ph or mi.

Serdyukova, A. S., and Kapitanov, Yu. T., 1958, Use of radiometric methods for simultaneous separate determination of U, Th, Ra and K in acid igneous rocks: Zh. Anal. khim. (U. S. S. R.), v. 13, no. 1, pp. 88-94. ATS 92M45R. $7.50.

Shcheglov, A. D., 1959, Some features of the formation of Hg-Sb-W deposits in the Transbaikal region: Vses. mineral. obshch., Zap. (U. S. S. R.), v. 88, no. 1, pp. 48-59. LC or SLA 60-23751. mi. $2.70; ph. $4.80.

Shturm, L. D., 1952, Morphological characteristics of sulfate-reducing bacteria encountered in oil-bearing formations: Tr. In-ta mikrobiol. AN SSSR, no. 2, pp. 3-32. ATS, RJ-170. $23.60.

Shur, Ya. S., 1958, The magnetic structure

of highly-coercive ferromagnetic materials: Tr. In-ta fiz. metallov, v. 20, pp. 111-124. NLL (LLU), M 1900. Loan through authorized library.

Silvestri, A., 1897, The genus Nubecularia de France; Atti accad. pontifica nuovi Lincei, v. 50, sess. 2a, pp. 29-36. ATS, 95-IJ. $5.75.

Simonyan, A. A., 1953, A field method for determining the limiting shear stress of peat: Torf. prom-st'., pp. 24-25. NLL(LLU), M.1526. Loan through authorized library.

Sobol', S. I., 1957, The conditions for the reduction of lead from its compounds in aqueous media by means of pressurised oxygen: Sb. nauch. tr., gos. nauch. -issled. in-ta tsvet. metallov, no. 13, pp. 115-122. NLL(LLU), RTS 1733. 20s (approx. $2.50)

Sorokin, Yu. I., New methods of isolation of sulfate-reducing bacteria: Tr. in-ta mikrobiol. AN SSSR, no. 2, 121-129. ATS, RJ-171. $9.50.

Stach, E., 1956, Some foraminifera in the oil shale of the Wellington seam of the Ruhr: Z. deut. geol. Ges., v. 107, pp. 116-119. ATS, 97-GJ. $7.40.

Starik, I. Ye. (ed), 1957, Works of the V. G. Khlopin Radium Institute: Tr. AN SSSR, Radiyev. in-ta, v. 6. OTS, AEC-tr-4208. $2.75.

Steinmann, G., 1902, A reef-building Nubecularia from the Sarmatian stage: Ann. K. K. Naturhist., Hofmuseums v. 17, pp. 112-116. ATS, 94-GJ. $5.75.

Stepanov, P. A., Sergeev, E. A., Belogragina, M. V. and Leshchinskaya, M.S., 1960. Rapid spectroscopic analysis of metallometric specimens for rare alkali metals, boron, fluorine and other elements: Izv. AN SSSR, ser. fiz. v. 23, no. 7, pp. 1141-1143. CTT. $8.00.

Sveshnikov, V.N., 1952, Solubility of dolomitized limestones and dolomites in water at 25°C and 1 ATM pressure of CO_2: Dokl. AN SSSR, v. 85, no. 2, pp. 357-360. LC or SLA 61-13686. $1.80, or ATS, RJ-380.

Tatarskii, V. B., 1952, Methods for the determination of rock-forming carbonate minerals: Gostoptekhizdat, Moscow-Leningrad. ATS, RJ-198. $38.00.

Thijsse, J. Th., 1950, Changes in water movements and bottom relief in the Wadden Sea: Tijdschr. koninkl. ned. aardrijks. geno. v. 67 (2), no. 3, pp. 334-335. ATS, 130-DU. $3.25.

Treibs, A., 1934, The occurrence of chlorophyll derivatives in an oil shale from the Upper Triassic: Ann., v. 509, pp. 103-114. ATS, 113-GJ. $8.95.

Triebs, A., 1935, Chlorophyll and hemin derivatives in bituminous rocks, petroleums, coals and phosphate rock: Ann., v. 517, pp. 172-196. ATS, GJ-112, $15.85.

Treibs, A., 1935, Porphyrins in coals: Ann. v. 520, pp. 144-150. ATS, 110-GJ. $18.80.

Treibs, A., and H. Steinmetz, 1933, The occurrence of anthraquinone dyes in the mineral kingdom (graebeite): Ann., v. 506, pp. 171-195. ATS, 114-GJ. $18.35.

Tricart, J., 1951, Techniques of Study. Determination of the direction of fluvial flow from an alluvial stratum: Rev. geomorph. dynamique, v. 2, no. 3, pp. 128-134. ATS, 105-FJ. $8.75.

Tugarinov, A. I., 1954, Reliability of the determination of the absolute age of uranium minerals from the ratio of lead isotopes: Dokl., AN SSSR, v. 99, pp. 1061-1063. ATS, RJ-260. $5.40.

Uropov, A. K., 1953, Multiple reflected and refracted waves as a factor decreasing the quality of seismic data on the Russian platform: Mosc. neft. in-ta, Trudy (U.S.S.R.), v. 12, pp. 80-91. LC or Sla 60-18917. $2.40 mi or $3.30 ph.

Vakar, V. A., Knipovich, Ye. V., and Shafranovskiy, I. I., 1934, Ludwigite from polar Yakutia, Vses. mineral. obshch., Zap. (U.S.S.R.), v. 63, pp. 381-385. LC or SLA 60-23738. $1.80, mi or ph.

Valyashko, M. G., 1956, Geochemistry of deposits of K salts: trans. of unidentified monogr., AN SSSR, otdel. geol. -geograf. nauk., pp. 182-207. LC or SLA 60-18927. mi. $3.60; ph. $9.30.

van Bendegom, L., 1950, Some observations concerning the formation and development of tidal flats: Tijdschr. koninkl. ned. aardrijks. geno., v. 67 (2), no. 3, pp. 326-333. ATS, 131-DU.

Van Veen, J., 1950, Ebb-and flood-channel systems in the Dutch tidal waters: Tijdschr. koninkl. ned. aardrijks. geno., v. 67 (2), no. 3, pp. 303-325. ATS, 136-DU. $21.90.

Vasil'eva, V.N., Dvorzhetskaya, L.A., Markovskii, L. Ya., and Khlebnikova, L. Ya., 1960, Spectrographic analysis of luminescence-pure zinc sulfide and sulfate with the aid of chemical enrichment: Izv. AN SSSR, v. 23, no. 7, pp. 1146-1147. CTT. $8.00.

Vdovykin, G. P., 1960. Preliminary results of a luminiscent-bituminous analysis of four carbonaceous chrondrites: Meteorika, v. 19, pp. 78-82. LC or SLA, UCRL Trans - 533. $2.40 mi; $3.30, ph.

Veen, J. Van: See Van Veen, J.

Vernadskii, V. I., Rare earth elements (Extraction, analysis, applications): AN SSSR, in-ta geokhim. i anal. khim., Moscow, 356. pp. OTS 60-51076. $2.75.

Vlasov, K. A., and Kutukova, Ye. I., 1960, Emerald mines (of the Urals): Trans. mono. Izumrudnyye kori, Moscow, pp. 3-4, 8-12, 80-82, 111-154 and 197-215. OTS 60-41716. $2.50.

von Engelhardt, W., and H. Luebben, Investigations of the influence of interfacial tension and contact angle upon the displacement of oil by water in porous bodies: Erdöl u. kohle v. 10, no. 12, pp. 826-830. ATS, 116-GJ. $8.25.

Weingaertner, E., et al., 1957, The use of phase separation methods for demineralizing athabasca bituminous sands: Erdöl u. kohle v. 10, no. 9, pp. 584-587. ATS, 124-GJ. $11.95.

Wicher, C. A., 1944, Micropaleontological reports, Data on genera Vidalina and Involutina: Palaeontol. Z., v. 23, pp. 244-253. ATS, 98-GJ. $10.95.

Yanat'eva, O. K., 1954, Solubility of dolomite in water in the presence of carbon dioxide: Izv. AN SSSR, Otdel. khim. nauk, no. 6, pp. 1119-1120. ATS, RJ-310. $4.40.

Yanovskaya, N. M., 1959, The All-Union Paleontological conference: Izv. AN SSSR, ser. biol., v. 24, no. 6, pp. 944-947. OTS 61-1105. $0.50.

Zhukova, A. I., 1955, Biomass of microorganisms in bottom sediments of the Northern Caspian: mikrobiol., v. 24, no. 3, pp. 321-324. ATS, RJ-287. $8.20.

Zlobin, B. I., The petrography and rock chemistry of the Sandyk Mountains alkalic intrusion (northern Kirgizia): A brief outline: Izv. AN SSSR, ser. geol., no. 2, pp. 91-104. NLL(LLU), RTS 1648. 35 s. (approx. $4.50).

Vernadskii, V. I., Rare earth elements (Extraction analysis, applications): AN SSSR, Izd-vo geokhim. nauchn. knigi, Moscow, 265 pp. OTS 60-31074. $2.75.

Vlasov, K. A., and Kutukova, Ye. I., 1960, Emerald mines (of the Urals): Trudy mineral. muzeya, Izumrudnyye kopi, Moscow, pp. 3-4, 5-12, 50-52, 111-184 and 199-215. (OTS 61-31116. $2.720

von Engelhardt, W., and H. Luebben, Investigations of the influence of interfacial tension and contact angle upon the displacement of oil by water in porous bodies: Erdöl u. Kohle, v. 10, no. 12, pp. 826-836. ATS, 110-44J. $8.25.

Weingaertner, E., et al., 1957, The use of phase separation methods for determining asphaltene in bituminous sands: Erdöl u. Kohle, v. 10, no. 9, pp. 584-587. ATS, 123-41J. $11.95.

Wicher, C. A., 1944, Micropaleontological